

Multum in Parvo :

O R;

TABLES

EXACTLY CALCULATED
For the Latitude of *LONDON*.

Teaching any *Person*, though of an ordinary Capacity and unlearned in the *MATHEMATICKS*, to draw a true *SUN-DIAL* on any *Vertical* or *Upright PLANE*, however *Situated* in respect of *Declination* : Only with the help of a pair of *Compasses* and a *Line of Chords* ; and without any *Arithmetical Calculation*.

The like never before Published.

To which is added a *TABLE* ; shewing the Distance of each *Hour-line* from the *Meridian* : Upon all *Horizontal Dials*, Calculated to every Degree of *Latitude*.

LIKEWISE,

SPOT, }
CONCAVE, } { INSTRUMENTAL
CONVEX, } { REFLEX,
 } { CYLINDRICAL
DIALING.

ALSO,

How to Adorn the said Dials, with all Useful

FURNITURE.

Relating to the
COURSE of the *SUN*.

By *John Good*. R

London : Printed for, and Sold by *Richard Mount*, and Company, in *Postern-Row*, on *Tower-Hill*. 1706.



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23 for 10 r. 10.

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A

NECESSARY INTRODUCTION;

Consisting of

PROBLEMS and DEFINITIONS;

Geometrical and Astronomical :

*For the more easie Apprehending, and ready Per-
forming, of the several Matters and Things
contained in the following Treatise.*

PROB. I.

Fig. I.

*Upon any Point [as O] taken in the Right-
Line $\angle R$, to erect a Perpendicular OS.*

1. **O** Pen your Compasses to any small Distance;
and setting one Foot in the given Point
O, with the other Foot make marks on both the
sides of O, as at T, and V.

2. Open the Compasses to any Distance, greater
than the former; and setting one foot in T, with
the other describe the Arch *hh*: Also, with the
same distance, set one foot in V, and with the o-
ther describe the Arch *gg*, crossing the former Arch
hh in the Point S.

B

3.

3. Draw the Line O S, and it will be *Perpendicular* to the given Line Q R.

PROB. II.

Fig. 2.

A Right-Line being given, how to draw another Right-Line, which shall be Parallel thereunto at any distance required.

LET the Line given be A B, unto which is required to draw another Right Line C D, which shall be Parallel to the former Line A B, and at the distance A C.

1. Open your Compasses to the Distance A C, then set one Foot in the point A, with the other describe the Arch C; Again place one Foot in B, and with the other describe the Arch D; then draw the Line C D so that it may only touch the two Arches C and D, so shall the Line C D so drawn, be Parallel to A B, and at the distance required.

Astronomical Definitions.

1. **T**HE Horizon is that part of the Heavens as a quick Eye can discern in an open Place; which divides the Heavens into two Equal Parts. The middle Point of the Heavens which is over our Heads, is called the *Zenith*; and that under our Feet the *Nadir*.

2. The *Meridian* is a great Circle of the Heavens, passing through the Poles, the *Zenith* and *Nadir*, in which the Sun is at Noon, and at Twelve a Clock at Night.

3. The

3. The *Equinoctial* is a great Circle of the Heavens, dividing it into the Northern and Southern Hemispheres; and takes their Names from the two Poles, that being call'd the *Northern Hemisphere*, in which the *North-Pole* is seated, and that the *Southern* in which the *South-Pole* is seated. Unto this Circle when the Sun in his Annual motion arriveth, [which is twice a Year] the Days and Nights are of an equal length through the whole World.

This Circle cutteth the *Axis* of the World at Right Angles, and is seated in the *Heavens* every ways 90 deg. distant from either of the Poles.

4. The two Tropicks are *Smaller Circles* of the *Heavens*, described parallel to the *Equinoctial Circle*, and at 23 deg. 30 min. distance therefrom; that being the greatest *Declination* that the Sun hath from the *Equinoctial* towards either of the Poles. Of these Circles one is called the *Tropick of Cancer*, or Northern Tropick; the other the *Tropick of Capricorn*, or Southern Tropick. These two Circles are the Bounds or Limits of the Sun's Course, for between them he always moveth, never going more Northward or Southward, [that is, declines not nearer to any of the Poles] than 23 deg. 30 min. Wherefore, when the Sun in his Annual motion, shall arrive to the *Tropick of Cancer*, which is about the 10th or 11th of *June*, he maketh the longest Days to all that Inhabit the Northern Hemisphere. And when he arriveth to the *Tropick of Capricorn*, which is about the 11th of *December*, he maketh the shortest Days to those that Inhabit the Northern, and the longest to those of the Southern Hemisphere.

How

*How to find a True Meridian line ; and
the Azimuth of the Sun.*

IT is very necessary to have a true *Meridian-line*, which may be obtained many ways, but the best I know for Practice is this ;

Get a plain thick Board of a Foot Square, or more, then in the middle, or as near as may be, fasten a strong Iron pin, about three Inches long, and make it so fast, that it will not shake or yield in the least : It matters not whether it be exactly Perpendicular, or not,

Set this Board Horizontally, with Earth or Sand upon the Ground ; about Nine a Clock see where the Head of this Iron-pin [which must be sharp at Top] giveth its shadow upon the Board, mark that Place : Then take a Wooden Ruler, sharp also at one End, and lay it so, upon the sharp End of the Iron-pin, that the sharp End of the Ruler, may touch the Mark, then carrying it steady, describe a Circle.

Come again about Three a Clock in the Afternoon, and mark where the Shadow of the Top of the Iron pin is in that Circle again.

Draw a line from those two Marks, which will be *East* and *West*, and the Perpendicular to that Line will be a True Meridian-line.

But because the Sun may be under a Cloud, when you come at Three a Clock, you may make Three or four more Circles, and use them as you used this.

When

When you have a True *Meridian-line*, you will easily find the Sun's *Azimuth*, or Distance from the *South*; for hold but up a Plumb-line, and the Angle which the Shadow maketh with the *Meridian-line*, is the *Azimuth*; or you may lay the Edge of your *Quadrant* to the *Meridian-line*, and the Shadow of the Plumb-line passing through the Center, will give you the *Azimuth* in the limb, and better than if you Calculated it by the Sun's *Altitude*.

P R O B. III.

Fig. 3.

The Latitude of the Place, the Declination of the Sun, and the Altitude of the Sun being given, to find the Azimuth, Geometrically

	deg.	min.	
The Latitude of the Place is	51	30	} North.
The Declination of the Sun is	20	9	
The Altitude of the Sun is	18	2	

I. Upon the Center Q, describe the Semi-circle HZO for half the Meridian, and upon Q, raise the Perpendicular QZ, for the Zenith.

II. Set 51 deg. 30 min. of your Line of Chords, which is the Latitude of *London*, from Z to Æ, and draw ÆQ for the Equinoctial.

III. Set 20 deg. 9 min. the Sun's Declination, from Æ towards Z, to the Point D, (being it is North) and draw the Line DT parallel to ÆQ, so is DBT the *Parallel of the Sun's Declination*.

IV. Set 18 deg. 2 min. the Sun's Altitude given, from O to L, and from H to M, and draw the Line ML, for the *Parallel of Altitude*.

V. Take

V. Take in your Compasses, half the length of the *Parallel of Altitude* SL, or SM, and with that distance upon Q, describe the innermost Semicircle ACG.

VI. From the Point B, which is where the *Parallel of Declination*, and the *Parallel of Altitude* do intersect, erect the *Perpendicular* BC, till it touch the innermost Semicircle.

VII. Lay a Ruler from Q to C, and it will cut the outermost Circle in E; so HE measured upon a Line of Chords, be 80 deg. the Sun's *Azimuth* from the *North* part of the *Meridian*.

VIII. EZ shall be 10 deg. the *Azimuth* from the *East* or *West*.

Lastly EO shall be 100 deg. the *Azimuth* from the *South* part of the *Meridian*.

Note; And whereas throughout this *Book* there is continual mention made of *Degrees* and *Minutes*; know, that a *Degree* is the 360th part of any *Circle*, each of which *Degrees* is supposed to be divided into 60 parts called minutes, so that 45 min. is three quarters of a *Degree*. 30 min. half a *Degree*, and 15 min. one quarter of a *Degree*, &c.

A Table of the Sun's Declination, Exactly Calculated for this present Year, 1706.

A Table of the Sun's Declination.

Days.	January		Febru.		March.		April.		May.		June.	
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.
1	21	S.41	13	S.44	03	S.23	08	N.38	18	N.05	23	N.10
2	21	31	13	24	03	00	08	58	18	20	23	14
3	21	21	13	04	02	36	09	20	18	34	23	17
4	21	10	12	44	02	13	09	41	18	44	23	20
5	20	59	12	23	01	48	10	03	19	03	23	23
6	20	47	12	02	01	25	10	24	19	17	23	25
7	20	36	11	41	01	02	10	45	19	30	23	26
8	20	23	11	20	00	38	11	05	19	43	23	27
9	20	10	10	58	00	14	11	26	19	56	23	28
10	19	57	10	37	00	N.10	11	47	20	09	23	29
11	19	43	10	15	00	33	12	07	20	21	23	29
12	19	29	09	53	00	57	12	27	20	33	23	29
13	19	15	09	31	01	20	12	47	20	44	23	28
14	19	00	09	08	01	44	13	07	20	55	23	27
15	18	45	08	47	02	08	13	26	21	06	23	25
16	18	30	08	24	02	31	13	46	21	16	23	23
17	18	14	08	01	02	54	14	05	21	26	23	21
18	17	58	07	39	03	18	14	23	21	35	23	18
19	17	42	07	16	03	41	14	42	21	45	23	14
20	17	26	06	53	04	04	15	00	21	54	23	11
21	17	09	06	30	04	28	15	18	22	02	23	07
22	16	51	06	07	04	51	15	36	22	11	23	02
23	16	34	05	53	05	13	15	54	22	18	23	57
24	16	16	05	21	05	37	16	11	22	27	22	52
25	15	58	04	57	05	59	16	28	22	33	22	66
26	15	40	04	34	06	22	16	45	22	39	22	41
27	15	21	04	10	06	45	17	01	22	45	22	34
28	15	02	03	47	07	07	17	18	22	51	22	27
29	14	43			07	29	17	33	22	56	22	20
30	14	24			07	52	17	50	23	02	22	12
31	14	04			08	14			23	06		

A Table of the Sun's Declination, Exactly Calculated for this present Year, 1706.

A Table of the Sun's Declination.

Days.	July.		August.		Septem.		October.		Novem.		Decem.	
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.
1	22	N. 04	15	N. 06	04	N. 18	07	S. 20	17	S. 42	23	S. 07
2	21	56	14	49	03	55	07	43	17	58	23	11
3	21	47	14	30	03	31	08	05	18	14	23	15
4	21	38	14	11	03	08	08	27	18	29	23	19
5	21	28	13	52	02	45	08	50	18	45	23	21
6	21	18	13	34	02	22	09	12	18	59	23	24
7	21	08	13	14	01	59	09	37	19	14	23	26
8	20	57	12	51	01	36	09	56	19	28	23	27
9	20	47	12	35	01	12	10	18	19	42	23	28
10	20	35	12	15	00	48	10	39	19	55	23	29
11	20	24	11	55	00	35	11	00	20	09	23	29
12	20	12	11	35	00	02	11	22	20	22	23	29
13	19	59	11	14	00	S. 22	11	48	20	34	23	28
14	19	46	10	54	00	45	12	04	20	46	23	26
15	19	33	10	33	01	09	12	25	20	57	23	25
16	19	20	10	12	01	32	12	45	21	09	23	22
17	19	07	09	51	01	56	13	05	21	20	23	19
18	18	53	09	30	02	19	13	24	21	30	23	16
19	18	39	09	08	02	43	13	44	21	40	23	13
20	18	24	08	47	03	06	14	05	21	50	23	09
21	18	09	08	25	03	29	14	24	21	59	23	04
22	17	54	08	03	03	52	14	44	22	08	22	59
23	17	38	07	41	04	16	15	03	22	16	22	53
24	17	22	07	19	04	39	15	22	22	24	22	47
25	17	06	06	56	05	02	15	40	22	31	22	41
26	16	50	06	34	05	26	15	58	22	39	22	34
27	16	34	06	12	05	45	16	16	22	45	22	27
28	16	17	05	49	06	12	16	34	22	51	22	19
29	15	59	05	26	06	35	16	51	22	58	22	11
30	15	42	05	03	06	58	17	08	23	02	22	02
31	15	24	04	40			17	25			21	53

How to find the *Situation* of any *Plane*, from the *South* or *North*, towards either *East* or *West*; Commonly called the *Declination* of a *Plane*.

The *Declination* of a *Plane*, is an Arch of the *Horizon* comprehended between the *Pole* of the *Plane*, and the *Meridian* of the *Place*. Or it is the distance of the *Plane* it self, from the prime *Vertical Circle*, or *Azimuth* of *East* and *West*.

To find out the *Declination* of any *Plane*, there are required two *Observations* to be made by the *Sun* at the same instant of time. The first of the *Sun's Horizontal distance* from the *Pole* of the *Plane*, and Secondly, of the *Altitude* of the *Sun*.

First, to find the *Sun's Horizontal distance* from the *Pole* of the *Plane*. Apply one edge of a *Quadrant*, to the *Horizontal-line* of your *Plane*, so that the other may be *Perpendicular* to it, and the *Limb* of the *Quadrant* must be towards the *Sun*, and hold the whole *Quadrant Horizontal* as near as you can conjecture: Then holding up a thread and plummet, at full liberty, so that the shadow of the thread, may pass both through the *Center* and *Limb* of the *Quadrant*, observe then the degrees cut by the shadow of the thread, and number them from that side of the *Quadrant* that standeth square or *Perpendicular* to the *Plane*: For those degrees are the *Horizontal distance* required.

Secondly, This *Horizontal distance* and the *Sun's Altitude* being observed at the same time (as near as may be) will help you to the *Plane's Declination*, by the Rules following.

First, by having the *Altitude*, you may find the *Azimuth*, by the foregoing *Problem* of the *Introduction*. Then by comparing the *Azimuth*, and the *Horizontal Distance* together, you may find the *Plane's Declination* in this manner.

When you make your *Observation*, of the *Sun's Horizontal Distance*, mark whether the shadow of the thread, fall between the *South*, and that side of the *Quadrant* which is *Perpendicular* to the *Plane*.

I. If the shadow fall between them, the *Azimuth* and *Distance* added together, do make the *Declination of the Plane*, and in this case the *Declination* is upon the *same Coast* whereon the *Sun's Azimuth* is.

II. If the shadow fall not between them, subtract the lesser of them from the greater, and the remainder shall be the *Plane's Declination*; and if the *Azimuth* be the greater of the two, the *Plane* Declines to the *same Coast* whereon the *Sun* is; but if the *Distance* be the greater, then the *Plane* Declines to the *contrary Coast*.

And here Note, that the *Declination* thus found is always accounted from the *South*, and that all *Declinations* are counted from either *South* or *North*, towards either *East* or *West*, and must never exceed 90 degrees.

I. If therefore the degrees of *Declination* do exceed 90, you must take the residue of that
Number

Number to 180, and that shall be the *Planes Declination* from the *North*.

II. If the degrees of *Declination* exceed 180, then the excess above 180 deg. gives the *Planes Declination* from the *North* towards that *Coast*, which is contrary to the *Coast* whereon the *Sun* is.

But seeing the *Declination* is the Angle contained between the *Perpendicular* from the *Wall* and the *Meridian*, it may be the best to wait in fair *Weather*, till you find the *Sun* in the *Meridian*; and then the Angle upon the *Limb* of the *Quadrant*, will it self be the *Declination*.

To find the *Hour* of the *Day*, and the *Azimuth* of the *Sun* at any time in the *Summer* half-year, by *Collins's Quadrant*. And,

First to rectify the *Bead*. Lay the thread over the *Day* of the *Month* in its proper *Circle*, and if the *Season* wherein the *Quadrant* is to be used, be in the *Winter* half-year, set the *Bead* by removing it to the *Winter-Ecliptick*; but in the *Summer* let it be set to the lower or *Summer-Ecliptick*, and then it is fitted for use.

One *Caution* in rectifying the *Bead* is to be given, and that in *Summer* time: If it be required to find the *Hour* and *Azimuth* of the *Sun* by the *Quadrant*, before the hour of 6 in the *Morning*, or after it in the *Evening*, or (which is all one) when the *Sun* hath less *Altitude* than he hath at 6 of the *Clock*; then must the *Bead* be rectified to the *Winter-Ecliptick*, and the *Parallels* above the *Horizon* in the *Reverted Tail*, are those which will come in use.

Example.

(42)
Example.

Admit when the Sun hath 19. deg. 13 min. of North Declination, which will be about the 6th of May, his observed *Altitude* were 56 deg. the Bead being set to the *Summer-Ecliptick*, and brought to that *Parallel of Altitude* amongst the *Altitudes*, the Thread in the Limb sheweth the true time of the Day to be either 7 min. past 11 in the Forenoon, or 53 min. past 12, and the Bead amongst the *Azimuths* shews the Sun's true Coast to be 23 deg. from the South, Eastward in the Forenoon, and Westward in the Afternoon.

To find what Altitude the Sun shall have at 6 of the Clock in the Summer half-Year.

THIS will be easily performed by bringing the Bead that is rectified to the *Summer-Ecliptick* to the left edge of the *Quadrant*, and there among the *Parallels of Altitude* it shews what *Altitude* the Sun shall have at 6 of the Clock: It also among the *Azimuths* shews what *Azimuth* the Sun will have at the hour of 6. *Example,* So when the Sun hath 17 degrees of North Declination, as about the 27th of April, his *Altitude* at the hour of 6 will be found to be 13 deg. 14 min. and his *Azimuth* from the Meridian 100 deg. 30 min. whence I may conclude if his observed *Altitude* be less upon the same Day, and the *Hour* and *Azimuth* sought, the Bead must be set to the *Winter-Ecliptick*, and the Operation performed in the *Reverted Tail*.

Hear

Here it may be noted also, That the exactest way of rectifying the Bead, will be either from a Table of the *Sun's Declination*, laying the Thread over the same in the graduated Circle, or from his true place, laying it over the same in the proper *Ecliptick*.

To find the Sun's Altitude on all Hours : at any Time proposed.

IN Summer time, if the Hour proposed be before 6 in the Morning, or after 6 in the Evening, lay the Thread to the hour in the Limb, the Bead being first rectified to the *Winter-Ecliptick*, and amongst the Parallels of *Altitude* above the upper *Horizon*, it shews the *Altitude* sought.

Example.

The Sun having 16 deg. of Declination Northward, as about the 24th of *April*, laying the Thread over the Declination, I set the Bead to the *Winter-Ecliptick*; and if it were required, to find what *Altitude* the Sun shall have at 36 min. past 6 in the Afternoon, lay the Thread over the same in the Limb, and the Bead among the *Parallels* of *Altitude* will fall upon 7 deg.

At all other times the Operation is alike; the Bead being rectified to that *Ecliptick* that is proper to the Season of the year : Lay the Thread over the proposed hour in the Limb, and the Bead amongst the *Parallels* of *Altitude*, sheweth the *Altitude* sought.

Another

Another Example.

So if it were required the same day to find what *Altitude* the Sun should have at 19 min. past 2 in the Afternoon; Lay the Thread in the Limb over the time given, and the Bead among the *Parallels* of *Altitude* will fall upon 45 deg. for the *Altitude* sought.

To find the Sun's Altitude on all Azimuths.

IN the Summer half-year, if the *Azimuth* proposed be more Northward than the *Azimuth* of the Sun shall have at the hour of 6; The Bead must be rectified to the *Winter-Ecliptick*, and brought to the *Azimuth* proposed above the upper *Horizon*, and there among the *Parallels* of *Altitude*, it sheweth the *Altitude* sought.

So about the 24th of *April*, when the Sun's Declination is 16 deg. his *Azimuth* at 6 of the Clock will be found to be 100 deg. 10 min. from the South; Then if it were required to find the Sun's *Altitude* upon an *Azimuth* more remote, as upon 107 deg. 54 min. from the South, laying the Thread over the Declination, I set the Bead to the *Winter-Ecliptick*, and afterwards carrying it to the *Azimuth* proposed among the *Parallels* of *Altitude* above the upper *Horizon*, it falleth upon 7 deg. for the Sun's *Altitude* sought.

In all other Cases bring the Bead (rectified to the *Ecliptick* proper to the Season of the year) to the *Azimuth* proposed; and among the *Parallels* of *Altitude* it sheweth the *Altitude* sought; So

So for the same day I set the Bead to the *Summer-Ecliptick*, and if it were required to know what *Altitude* the Sun shall have when his *Azimuth* is 50 deg. 48 min. from the *Meridian*, carry the Bead to the said *Azimuth*, and among the *Parallels of Altitude* it will fall upon 45 deg. for the *Altitude* sought.

The Altitude of the Sun being given, how to find the Hour of the Day, and the Azimuth of the Sun in Winter.

Rectifie the Bead to the *Winter-Ecliptick*, and carry it along among the *Parallels of Altitude* till it touch or intersect that *Parallel of Altitude* on which the *Sun* was observed, and the Thread in the Limb sheweth the *Hour* of the Day, and the Bead amongst the *Azimuths* sheweth the *Sun's Azimuth*.

Example.

So about the 18th of *October*, when the *Sun's Declination* is 13 deg. 10 min. *South*, if his observed *Altitude* were 18 deg. the true time of the Day would be found to be either 36 min. after 9, or 24 min. past 2; and his *Azimuth* would be 37 deg. from the *South*.

A Description of Dialling.

DIALLING is an Art teaching how to Measure the time of the Day, by the shade of the Sun; And originally is a *Mathematical Science*, attained by the Philosophical contemplation of the motion of the Sun, the motion of the Shadow, the Constitution of the Sphere, the Situation of Planes, and the consideration of Lines.

The motion of the Sun is regular, it moving equal Space in equal Time; But the motion of the Shadow irregular in all parts of the Earth, unless under the two Poles, and that more or less according to the Constitution of the Sphere, and the Situation of the Plane.

And therefore by Art there is found out Rules to mark out the irregular motion of the Shadow in all Latitudes, and on all Planes, to comply with the regular motion of the Sun. And these Rules of adjusting the motion of the Shadow to the motion of the Sun, may be called the Art of Shadows.

Of the several sorts of Planes upon which DIALS are usually made.

Definitions.

A Dial Plane is that Flat whereon a Dial is intended to be made.

Of Dial Planes some be *Direct*, others *Decliners*, and others *Oblique*.

Of *Direſt Planes* there are five ſorts.

1. The *Horizontal* whoſe Plane lies flat, and is parallel to the *Horizon*; beholding the *Zenith*.

2. The *South Ereſt*, whoſe Plane ſtands upright, and direſtly beholds the *South*.

3. The *North Ereſt*, whoſe Plane ſtands upright, and direſtly beholds the *North*.

4. The *East Ereſt*, whoſe Plane ſtands upright, and direſtly beholds the *East*.

5. The *West Ereſt*, whoſe Plane ſtands upright, and direſtly beholds the *West*.

Of *Decliners* there are infinite; and yet may be reduced into theſe two *Kinds*.

1. The *South Ereſt Plane*, declining more or leſs towards the *East* or *West*.

2. The *North Ereſt Plane*, declining more or leſs towards the *East* or *West*.

Of *Oblique Planes* ſome are *Direſt*, others *Declining*; and are of four ſorts; but of them I ſhall not Treat.

Note 1. That all Angles are uſually meaſured by a Line of Chords, whoſe *Radius* or *Semi-diameter* is equal to the Chord of 60 deg. and do contain 90 deg. which is a *Quadrant*; ſometimes by a *Tangent-line*.

2. If the Hours of a *Dial* be never ſo truly drawn, if the *Stile* be not well plac'd, it will not go exact; therefore obſerve theſe three Rules in ſetting your *Stile*.

1. That it has the ſame Center [if there be any] with the *Subſtile* and Hours.

2. Its due Angle.

3. That it ſtands *perpendicular* to the *Subſtile*.

Multam in Parvo :

O R,

TABLES, &c.

CHAP. I.

Fig. 4.

How to draw an Horizontal Dial.

1. **D**RAW the line *AB*, for 6 and 6 Morning and Evening.

2. Draw *NS*, *perpendicular* to *AB*; this shall be the 12 a Clock *Hour-line*.

3. Let *C*, the Intersection of the foresaid Lines be the *Center* of the *Dial*, then take in your *Compasses* 60 deg. of a *Line of Chords*, and with that distance upon the *Center C* draw an obscure Segment of a Circle, as *Amb*.

4. Turn to your *Table of Horizontal Spaces*, and see what *Degrees* and *Minutes* answer to 11 and 1 a Clock; you find they are 11 deg. 51 min. take therefore 11 deg. 51 min. out of your *Line of Chords*, and set it from *m* to *aa*, on both sides the 12 a Clock line.

Likewise take 24 deg. 20 min. for 10 and 2 a Clock, and set it from *m* to *bb*. Take 38 deg. 4 min. and set from *m* to *cc*; work after the same manner for the remaining hours.

5. From

5. From the Center *C*, thro' each of these Points *a, b, c, d, e*, draw lines, which shall be the hours required. The Intermedial Spaces, viz. Quarters, Half, and Three Quarters of an hour, are drawn after the same method.

Lastly, The Stile of your Dial must always make an Angle equal to the Latitude of the Place. Take therefore 51 deg. 30 min. out of your Line of Chords and set it from *m* to *n*, thro' *C* and *n* draw the line *C n*.

Note 1. That the Stile must stand at Right Angles with the Plane upon the 12 a Clock line.

2. That the 12 a Clock line must be set exactly North and South.

3. That the whole Plane must be laid parallel to the Horizon.

4. That the 2 hours above the Line of 6, are drawn by extending the two opposite Hour-lines thro' the Center, as 4 in the Morning is drawn by extending 4 in the Afternoon, &c.

CHAP. II.

Fig. 5.

How to draw the Hour-lines upon a Direct South Dial.

There is little difference between describing a South Dial and an Horizontal Dial; only Observe,

1. That the Angle which every Hour-line makes with the Meridian must be taken from the Table of South Dial Spaces, and prickt down on the Segment of the Circle *A, B, m*, as before directed in the Horizontal Dial.

2. That

2. That the Angle which the Stile makes with the *Meridian* must be 38 deg. 30 min. always the Complement of your *Latitude*.

Note ; That the Stile must stand at Right Angles with the *Plane*.

2. That the Face of the *Dial* must look exactly *South*, and be placed *perpendicular* to the *Horizon*.

CHAP. III.

Fig. 6.

How to draw the Hour-lines upon a Direct North Dial.

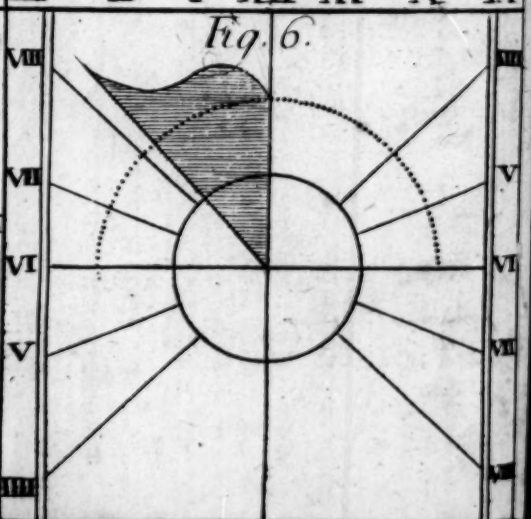
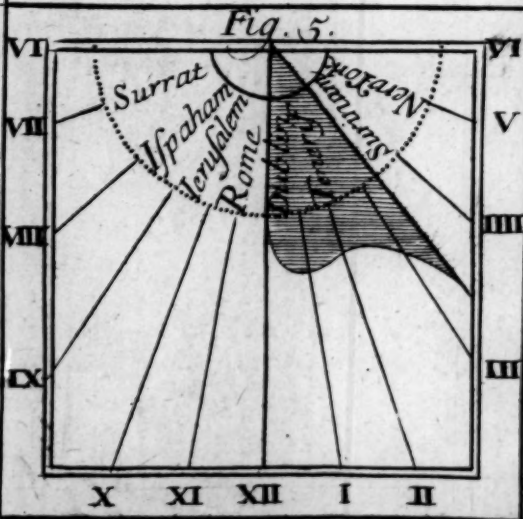
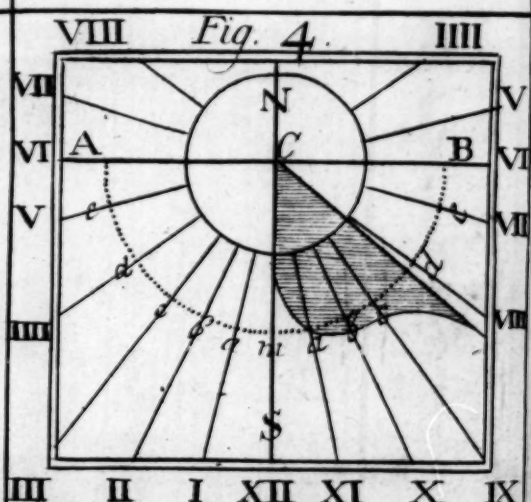
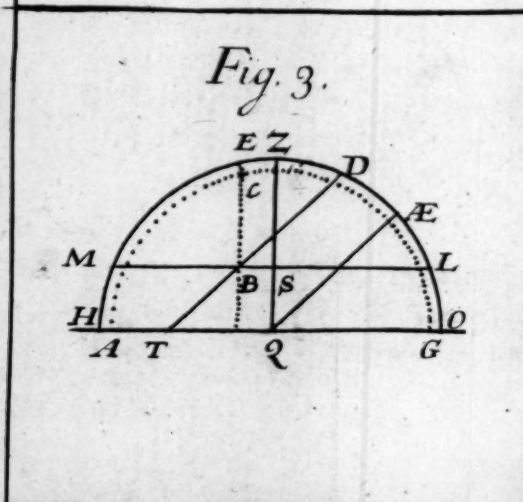
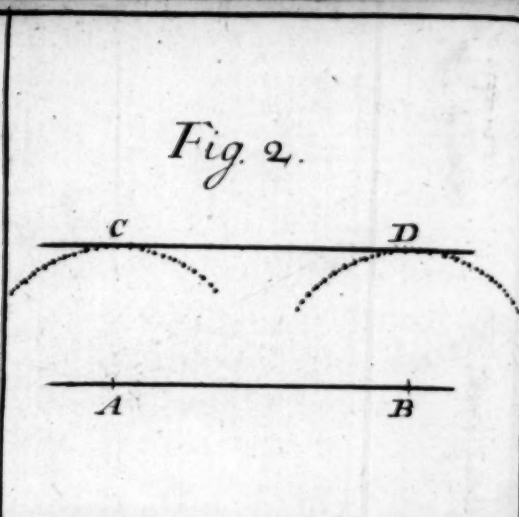
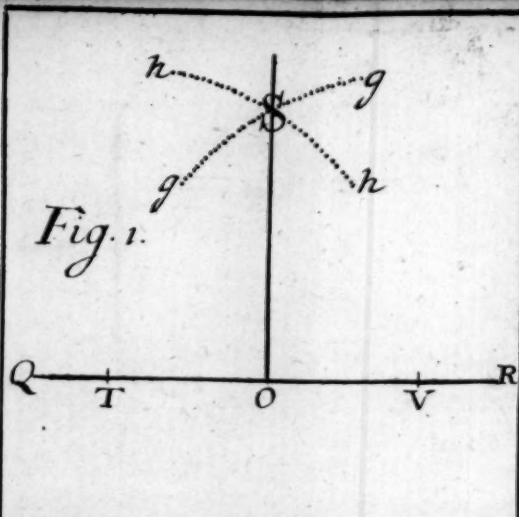
A *Direct North Dial*, is the same with a *Direct South Dial* ; for, if you take a *South Dial* and turn it upside down, causing the Stile to point upwards, as the Stile of the *South* doth downwards, and leaving out the Hours near the *Meridian*, in these *Northern Latitudes* : as the Hours of 9, 10, 11, and 12 at Night, and 1, 2, and 3 in the Morning, all which time the Sun is under the *Horizon*. I say a *South Dial* so inverted, and fixed against a *direct North Wall*, shall give the true hour of the Day.

CHAP. IV.

Fig. 7.

How to draw the Hour-lines upon a Direct, East or West Dial.
See a clearer way in a Dictionary of Arts & Sciences

1. **U**PON the point C, if it be an *East Dial*, or upon the point D, if a *West*, with 60 deg. of your line of Chords draw an obscure Segment of



of a Circle EF; then take 38 deg. 30 min. the Complement of your *Latitude*, and set it from E to F, and draw CF thro' the *Plane*. Call this Line the *Equinoctial*.

2. Assume any two points in this *Equinoctial* at a convenient distance for the *Hour-lines* of 11 and 6; and thro' these points GH, draw *perpendiculars* to the *Equinoctial*.

3. On G with 60 deg. of your Line of Chords, describe an obscure Arch of a Circle IK, and set thereon 15 deg. from I to K, and draw the Line GK, to cut the *Hour-line* of 6 in the Point L, so shall LH be the height of the *perpendicular* *Stile* proportioned to this *Plane*.

4. Upon L with 60 deg. of Chords, describe an Arch of a Circle M, N: between the *Hour-line* 6 and G L. Divide the Arch MN, into five equal parts with 15 deg. of Chords. Then turn to your Table for *East* and *West Dials*, and see what number stands against each hour, [and the Intermediate Spaces, if you please to put them in] take the said numbers out of your Line of Chords, and put them upon the Arch MN, from M to N.

5. Lay a Rule from L to each of the Divisions $\odot\odot\odot$, &c. and where the Rule intersects the *Equinoctial* line, make marks $***$, &c. Lines drawn thro' these points $***$, &c. Parallel to the *Hour-line* of 6, shall be the true *Hour-lines* for an *East Dial* from 6 to 11; but if you transfer the same distances on the *Equinoctial* before 6, as there is after 6, and thro' these distances draw lines parallel to 6; you have also the hours before 6, as 5, 4, &c.

Note

Note; 1. That the *Stile* may be a plate of Brass or Iron of the same breadth as is the distance between 6 and 9 on the *Equinoctial*, and fixed upon the line of 6, *perpendicular* to the *Plane*.

2. That an *East* and *West Dial* is the same in all Respects, save that the hour lines of 4, 5, 6, 7, 8, in the Morning in the *East Dial*, must be 8, 7, 6, 5, 4, in the Evening on the *West Dial*.

CHAP. V.

Fig. 8

How to draw the Hour-lines upon South or North Planes, Declining either East or West, 30 deg.

1. **D**RAW the Line NS for 12 a Clock Hour-line:

2. In this Line choose a Center as C, upon which with 60 degrees of Chords, describe an obscure Circle.

3. Turn to your Table of *Requisites*, and see what is the Substiles distance for 30 degrees of Declination; 'Tis 21 deg. 40 min. take the said distance out of your Line of Chords, and set it from M to S: thro' C and S draw an obscure Line for the Substile.

4. Now turn to your *Declination*, in the Tables of *Hour distances* from the Substile, and see what numbers stands against each Hour [and $\frac{1}{4}$ part, if you would insert them in your *Dial*] transfer these numbers by help of your Line of Chords into the Circle from S, towards A B; and thro' the Points draw Lines from C, the Center of your *Dial*; these are the hours required.

5. And *Lastly*, In your Table of *Requisites*, under the *Stiles* height, and opposite to 30 deg. of *Declination*, you'll find 32 deg. 37 min. Set this distance from S to T, then draw CT, and you have the height of the *Stile* or *Gnomon*.

Note 1. That the larger the Radius of your Line of Chords is, the better you may insert the *Hour-lines*.

2. If the *Declination* be *East*, the *Substile* must be placed on the left side of the *Meridian*; and those hours that are next to the numbers in your Table must be used: but the contrary, if the *Declination* be *West*.

3. If the Face of your *Dial* be towards the *North*, you must turn the *Dial* bottom upward; and reckon the Hours the contrary way; So a *South East Decliner*, will be a *North East Decliner*, and a *South West Decliner*, will be a *North West Decliner* leaving out the *Hour-lines*, [which will be needless] before *Sun-setting*, and after *Sun-rising*.

4. That the *Stile* must be fix'd upon the *Substile*, and stand at Right Angles with the *Plane*.

CHAP. VI.

Fig. 9.

How to draw the Hour-lines upon an Equinoctial Plane.

1. **D**RAW the Right Line AB, for the Horizontal Line of the *Plane*, and cross it about the middle thereof at Right Angles, with a Line 12 Q 12, for the *Meridian* and *Hour-line* of 12.

2. Upon

2. Upon the Line 12 Q 12, either above or below Q, assume any point as S, and setting one foot of your Compasses therein, [it being opened to the *Radius* of your Line of Chords] describe the Circle CDE, which divide into 12 equal parts beginning at D.

3. Lay a Rule to S, and the several points $\odot\odot\odot$, &c. and it will cut the Line AB, in the points $***$, &c.

Lastly, Through these points $***$, &c. draw Right Lines all *parallel* to the Line 12 Q 12, and so your *Dial* is finished.

The *Stile* may be either a streight Pin, of the length of the Line QS, and set perpendicular to the Plane, upon the the point Q; the shadow of the Top thereof only giving the Hour.

Or it may be a plate of Brass or Iron, of the breadth of the distance that is between the *Hour line* of 12 and 3, or 12 and 9. And then will the shadow of the upper edge thereof give the true hour of the Day.

C H A P. VII.

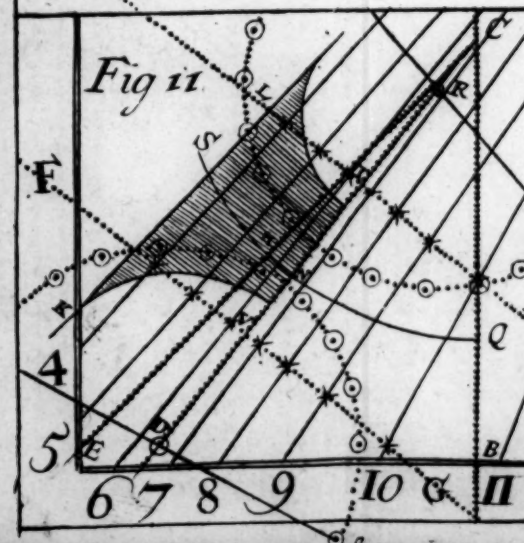
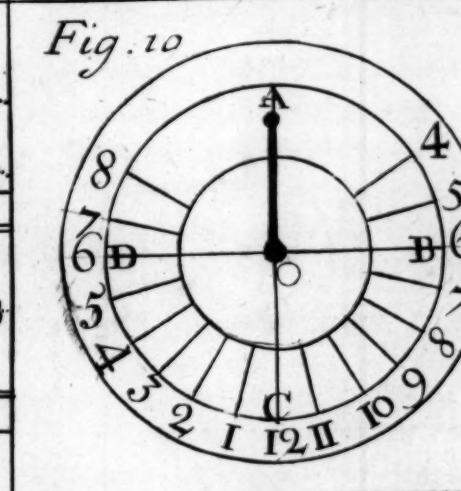
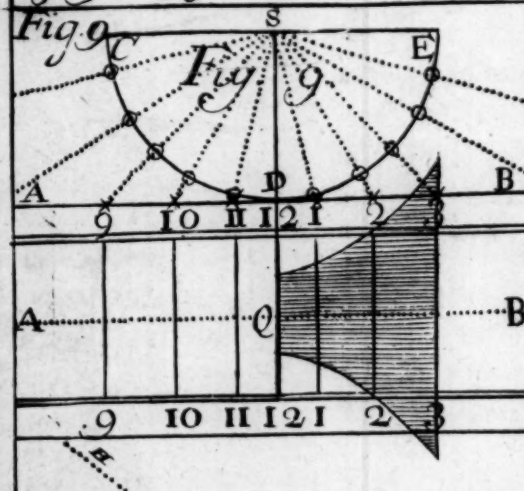
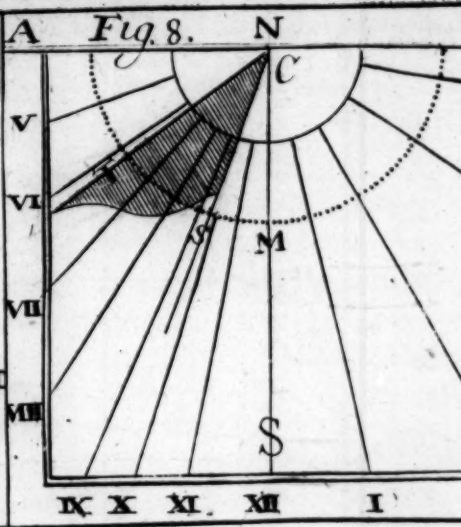
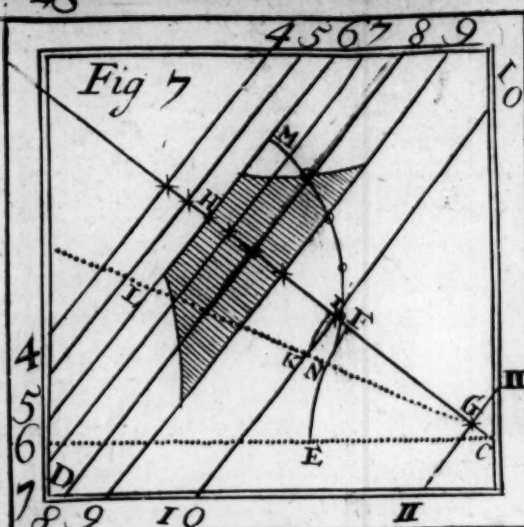
Fig. 10

How to draw the Hour-lines upon a Direct Polar Plane.

1. **D**escribe the Circle ABDE with 60 degrees of your Line of Chords.

2. Draw the Diameters AC and AD at Right Angles, in the Center O. AC shall be the hour of 12, and BD the hour of 6.

3. Turn to your Table of *Polar Dial*, and see what numbers answer to every hour; take the said numbers from your Line of Chords, and prick



prick them down in the Circle ABCD, on both sides the 12 a Clock-line: Draw lines from these Points thro' the Center O, and your work is done.

Note 1. That this *Plane*, by reason of its *North Reclination*, is in Summer, capable of receiving all the Hours from *Sun-rising* to *Sun-setting*, and therefore the *Hour-lines* of 4 and 5 in the Morning, and of 7 and 8 at Night, must be drawn through the Center, as you did in the *Horizontal Dial*.

2. That the Hour-Line of 12 must stand exactly *North* and *South*.

3. That the *Plane* must be elevated the same number of degrees towards the *South*, as the *Equator* is in your *Latitude*.

4. The *Stile* must be a streight Pin or Wire, (set perpendicular to the *Plane*, from the Center O) of any length.

5. The *South-inclining Plane* opposite to this, is directly the same, only the Forenoon hours in this must be the Afternoon in that, and the hours of 4 and 5 in the Morning, and of 7 and 8 in the Evening, must be omitted.

CHAP. VIII.

Fig. II.

How to draw the Hour-lines upon Far-Declining Dials.

BEcause the Tables extend no farther than 60 deg. of Declination, [and if they had been Calculated to 90 deg. they would have been of little use, because the *Stile's* height being so small,

small, the *Hour-lines* would have been of no Competent Distance] and because many times there may be Occasion to make a *Dial* for a greater Declination, I will shew a *Geometrical* way to draw such, by the help of a Line of Chords only.

Let the Declination given be 80 deg. Eastwards.

1. Draw a line BC, perpendicular to the *Horizon* of the *Plane*.

2. Upon C, with a Chord of 60 deg. describe the Arch QS, then out of the Table of *Requisites* take the Substile's distance, and set it from Q to N; take also the Stile's height, and set it from N to b.

3. Draw CD for the Substile, and CE for the Stile: Then at any convenient distance draw KL, parallel to CE the Stile. Also assume any two points in the Substile, and thro' them draw the perpendiculars FG, and HI.

4. Take the nearest distance from T to KL, and from V to KL, and set it from T to R, and from V to D.

5. Upon D and R, with 60 deg. of Chords, describe two Arches of a Circle, and set off the Inclination of the *Meridian* from T to P, and from V to O. With 15 deg. of Chords divide the Segments into equal parts, beginning at O and P.

6. Lay a Rule on D, and on each division in the Arch VO, and mark the Intersection of the Rule with the Line FG. Then lay the Rule to R, and work after the same manner in the other Arch, and HI.

7. Thro' the marks made in HI, and GF, draw the *Hour-lines*.

Note 1. When the *Plane* declines *Westward*, the perpendicular CB must be put on the *Right-hand*.

2. That

2. That the Inclination of the *Meridian* must be set on the same side of the *Substile* with the *Perpendicular*.

Thus have you finished your *Dial*, and in the making of this you have made a *South* declining *West* 80 deg. also; for if you turn the Paper, and look through it, it will on the back-side be a *South* declining *West* 80 deg. only the Forenoon hours in this, must be Afternoon in that: Nay, of right, you have made in this one *Dial* Four, viz. a *North*, declining either *East* or *West*, if you well observe what was said of the *Dial* declining 30 deg.

CHAP. IX.

How to place an Upright Dial truly.

ALL *Upright Dials*, in what Lat. soever, have the *Mer.* perpendicular to the *Hor.* Therefore to set your *Dial* exact, hang a Line with a Plummet at the end thereof, upon a nail fixt in the line of 12 toward the top; then apply your *Dial* to the place where it is to be fixt, so that the line and plummet may hang just down upon the line of 12: The *Dial* thus fixt (if the *Declination* be truly taken, and the *Dial* made by the former directions) will at all times (if the *Sun's* on it) give the true hour of the day.

Note. In every *Dial* truly placed, if you stand on the *South-side* of the *Plane* looking *Northward*, the *Hours* on your *left-hand* of the *Mer.* are the *Morning-Hours*, on your *right-hand* are the *Evening-Hours*; but if you stand on the *North-side* of the *Plane*, your *Face* being *Southward*, then the *Forenoon-Hours* are on your *right-hand*, and the *Afternoon-Hours* on your *left-hand*; because your *right-hand*, in relation to the *Plane*, is where your *left-hand* was.

The Three Requisites in Dialling, Calculated
to every Degree of Declination, in the
Latitude 51 deg. 30 min.

Declination.	Sub- stile's Di- stance Meri- dian.		Stile's height.		Incli- nation of Me- ridian.		Declination.	Sub- stile's Di- stance Me- ridian.		Stile's height.		Incli- nation of Me- ridian.	
	d.	m.	d.	m.	d.	m.		d.	m.	d.	m.	d.	m.
1	00	48	38	29	01	17	22	16	36	35	16	27	18
2	01	36	38	28	02	33	23	17	16	34	57	28	39
3	02	23	38	26	03	49	24	17	56	34	39	29	38
4	03	11	38	23	05	07	25	18	34	34	21	30	47
5	03	58	38	20	06	23	26	19	13	34	01	31	56
6	04	45	38	15	07	39	27	19	50	33	42	33	04
7	05	32	38	10	08	55	28	20	29	33	20	34	12
8	06	19	38	04	10	11	29	21	05	32	59	35	19
9	07	05	37	57	11	27	30	21	40	32	37	36	25
10	07	52	37	49	12	42	31	22	15	32	15	37	31
11	08	38	37	40	13	57	32	22	50	31	52	38	36
12	09	23	37	30	15	10	33	23	25	31	27	39	41
13	10	08	37	21	16	26	34	23	59	31	04	40	46
14	10	54	37	10	17	40	35	24	31	30	40	41	49
15	11	38	36	58	18	54	36	25	04	30	14	42	52
16	12	22	36	43	20	07	37	25	35	29	48	43	55
17	13	05	36	32	21	20	38	26	04	29	22	44	58
18	13	49	36	18	22	33	39	26	35	28	56	45	59
19	14	31	36	03	23	45	40	27	03	28	29	47	00
20	15	13	35	48	24	57	41	27	33	28	01	48	00
21	15	54	35	31	26	08	42	28	01	27	33	49	00

The Three Requisites in Dialling, Calculated
to every Degree of Declination, in the
Latitude 51 deg. 30 min.

Declination.	Sub- stile's Di- stance Meri- dian.		Stile's height.		Incli- nation of Me- ridian.		Declination.	Sub- stile's Di- stance Meri- dian.		Stile's height.		Incli- nation of Me- ridian.	
	d.	m.	d.	m.	d.	m.		d.	m.	d.	m.	d.	m.
43	28	29	27	05	50	00	67	36	13	14	05	71	38
44	28	35	26	36	50	59	68	36	25	13	29	72	27
45	29	21	26	07	51	57	69	36	36	12	33	73	16
46	29	46	25	37	52	55	70	36	46	12	18	74	06
47	30	11	25	07	53	53	71	36	55	11	41	74	55
48	30	35	24	38	54	50	72	37	06	11	06	75	44
49	30	58	24	06	55	46	73	37	15	10	29	76	33
50	31	21	23	35	56	42	74	37	24	09	33	77	21
51	31	45	23	04	57	38	75	37	32	09	16	78	09
52	32	05	22	32	58	33	76	37	40	08	40	78	57
53	32	26	22	00	59	28	77	37	47	08	03	79	46
54	32	46	21	28	60	23	78	37	57	07	27	80	33
55	33	06	20	55	61	17	79	37	59	06	49	81	21
56	33	24	20	22	62	10	80	38	04	06	12	82	09
57	33	42	19	49	63	04	81	38	09	05	35	82	56
58	34	00	19	16	63	57	82	38	14	04	58	83	43
59	34	15	18	42	64	49	83	38	17	04	20	84	31
60	34	33	18	06	65	41	84	38	21	03	44	85	18
61	34	47	17	34	66	33	85	38	23	03	06	86	05
62	35	05	17	00	67	24	86	38	26	02	28	86	52
63	35	18	16	25	68	16	87	38	28	01	52	87	39
64	35	34	15	50	69	07	88	38	29	01	15	88	26
65	35	47	15	15	69	57	89	38	29	00	37	89	13
66	36	00	14	40	70	47	90	38	30	00	00	90	00

A TABLE of Horizontal Spaces, shewing the Distance of each *HOUR-LINE* from the *MERIDIAN*: upon all *HORIZONTAL* Planes, also upon *DIRECT NORTH* or *SOUTH* Planes, whether *Erect*, *Reclining* or *Inclining*: Calculated to every Degree of *LATITUDE*.

An Horizontal Dial, Latitude.	xi. i.		x. ii.		ix. iii.		viii. iv.		vii. v.		vi.		A Direct South Dial, Latitude.
	d. m.		d. m.		d. m.		d. m.		d. m.		d. m.		
	—	—	—	—	—	—	—	—	—	—	—	—	
0	0	0	0	0	0	0	0	0	0	0	00	00	90
1	0	16	0	34	1	0	1	44	3	44	90	00	89
2	0	32	1	9	2	0	3	27	7	25	90	00	88
3	0	48	1	44	3	0	5	11	11	3	90	00	87
4	1	5	2	19	4	0	6	54	14	36	90	00	86
5	1	20	2	52	4	58	8	35	18	1	90	00	85
6	1	36	3	27	5	58	10	16	21	19	90	00	84
7	1	52	4	3	6	57	11	55	24	27	90	00	83
8	2	8	4	37	7	55	13	33	27	23	90	00	82
9	2	23	5	9	8	54	15	10	30	17	90	00	81
10	2	40	5	43	9	51	16	44	32	57	90	00	80
11	2	55	6	17	10	48	18	17	35	27	90	00	79
12	3	11	6	51	11	45	19	48	37	49	90	00	78
13	3	27	7	24	12	41	21	17	40	1	90	00	77
14	3	43	7	57	13	36	22	44	42	4	90	00	76
15	3	58	8	30	14	31	24	9	44	0	90	00	75
16	4	13	9	2	15	25	25	31	45	49	90	00	74
17	4	29	9	35	16	26	26	52	47	26	90	00	73
18	4	44	10	8	17	10	28	9	49	4	90	00	72
19	4	59	10	39	18	2	29	25	50	33	90	00	71
20	5	14	11	10	18	53	30	39	51	55	90	00	70
21	5	29	11	41	19	44	31	50	53	9	90	00	69
22	5	44	12	13	20	32	32	58	54	21	90	00	68
23	5	59	12	43	21	20	34	5	55	30	90	00	67
24	6	13	13	13	22	8	35	10	56	37	90	00	66
25	6	28	13	43	22	55	36	12	57	34	90	00	65
26	6	42	14	12	23	40	37	13	58	34	90	00	64

A TABLE of *Horizontal Spaces, &c.*

An Horizontal Dial, Latitude.	xi. i.		x. ii.		ix. iii.		viii. iv.		vii. v.		vi.		A Direct South Dial, Latitude.
	d. m.		d. m.		m. d.		d. m.		d. m.		d. m.		
27	6	56	14	41	24	25	38	11	59	27	90	00	63
28	7	10	15	10	25	9	39	7	60	17	90	00	62
29	7	24	15	40	25	52	40	2	61	4	90	00	61
30	7	38	16	6	26	33	40	54	61	49	90	00	60
31	7	50	16	34	27	15	41	44	62	30	90	00	59
32	8	5	17	1	27	55	42	30	63	11	90	00	58
33	8	19	17	27	28	34	43	20	63	49	90	00	57
34	8	31	17	54	29	13	44	5	64	24	90	00	56
35	8	44	18	20	29	50	44	49	64	58	90	00	55
36	8	57	18	45	30	27	45	31	65	30	90	00	54
37	9	10	19	9	31	2	46	12	66	10	90	00	53
38	9	22	19	34	31	37	46	50	66	29	90	00	52
39	9	34	19	58	32	11	47	28	66	56	90	00	51
40	9	45	20	21	32	44	48	7	67	21	90	00	50
41	9	57	20	44	33	16	48	39	67	47	90	00	49
42	10	10	21	7	33	46	49	12	68	11	90	00	48
43	10	22	21	29	34	18	49	44	68	33	90	00	47
44	10	32	21	51	34	47	50	10	68	54	90	00	46
45	10	43	22	12	35	17	50	46	69	15	90	00	45
46	10	54	22	33	35	44	51	15	69	35	90	00	44
47	11	05	22	53	36	11	51	42	69	53	90	00	43
48	11	17	23	13	36	37	52	9	70	11	90	00	42
49	11	25	23	33	37	3	52	35	70	28	90	00	41
50	11	35	23	52	37	28	53	00	70	43	90	00	40
51	11	45	24	9	37	52	53	24	70	59	90	00	39
52	11	55	24	27	38	15	53	46	71	13	90	00	38
53	12	5	24	43	38	37	54	18	71	28	90	00	37
54	12	13	25	2	38	58	54	29	71	41	90	00	36
55	12	22	25	18	39	19	54	49	71	54	90	00	35
56	12	32	25	34	39	40	55	9	72	5	90	00	34
57	12	40	25	50	39	59	55	28	72	17	90	00	33
58	12	48	26	5	40	18	55	45	72	28	90	00	32

A TABLE of Horizontal Spaces, &c.

As Horizontal Dist., Latitude.	xi.		i. x.		ii. ix.		iii.		viii. iv.		vii. v.		vi.		A Direct South Dist., Latitude.
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	
59	12	56	26	20	40	36	56	3	72	38	90	00	31		
60	13	4	26	34	40	54	56	19	72	48	90	00	30		
61	13	11	26	47	41	10	56	34	72	58	90	00	29		
62	13	19	27	1	41	21	56	49	73	7	90	00	28		
63	13	26	27	13	41	42	57	3	73	13	90	00	27		
64	13	32	27	25	41	57	57	17	73	24	90	00	26		
65	13	39	27	37	42	15	57	30	73	32	90	00	25		
66	13	45	27	49	42	25	57	43	73	39	90	00	24		
67	13	51	27	59	42	38	57	54	73	46	90	00	23		
68	13	57	28	9	42	50	58	5	73	53	90	00	22		
69	14	3	28	19	43	2	58	16	73	59	90	00	21		
70	14	8	28	29	43	13	58	26	74	05	90	00	20		
71	14	13	28	37	43	18	58	35	74	11	90	00	19		
72	14	18	28	46	43	24	58	44	74	16	90	00	18		
73	14	22	28	54	43	36	58	52	74	20	90	00	17		
74	14	27	29	2	43	52	59	00	74	25	90	00	16		
75	14	30	29	7	44	00	59	7	74	30	00	00	15		
76	14	33	29	15	44	8	59	15	74	34	90	00	14		
77	14	37	29	21	44	14	59	22	74	37	90	00	13		
78	14	41	29	27	44	22	59	27	74	41	90	00	12		
79	14	44	29	32	44	28	59	32	74	44	90	00	11		
80	14	47	29	37	44	34	59	37	74	47	90	00	10		
81	14	49	29	41	44	37	59	40	74	49	90	00	9		
82	14	51	29	45	44	40	59	44	74	51	90	00	8		
83	14	53	29	49	44	44	59	47	73	53	90	00	7		
84	14	55	29	52	44	48	59	51	74	55	90	00	6		
85	14	56	29	54	44	53	59	54	74	57	90	00	5		
86	14	57	29	55	44	55	59	55	74	58	90	00	4		
87	14	58	29	56	44	56	59	56	74	58	90	00	3		
88	14	59	29	57	44	57	59	58	74	59	90	00	2		
89	14	59	29	58	44	58	59	59	74	59	90	00	1		
90	15	00	30	00	45	00	60	00	75	00	90	00	0		

A Table of *Horizontal Spaces*, Exactly Calculated for the *Latitude* of *LONDON*: Shewing what Angle, every Five Minutes makes with the *Meridian*, upon an *Horizontal Dial*.

Hours.	d. m.	Hours.	d. m.	Hours.	d. m.
xii.	00 00	ii. x.	24 20	iiii. viii.	53 36
5 55	00 59	5 55	25 25	5 55	54 59
10 50	01 58	10 50	26 30	10 50	56 23
15 45	02 57	15 45	27 37	15 45	57 48
20 40	03 55	20 40	28 44	20 40	59 14
25 35	04 54	25 35	29 51	25 35	60 40
30 30	05 53	30 30	30 59	30 30	62 10
35 25	06 53	35 25	32 00	35 25	63 35
40 20	07 52	40 20	33 18	40 20	65 04
45 15	08 51	45 15	34 29	45 15	66 34
50 10	09 51	50 10	35 40	50 10	68 04
55 5	10 51	55 5	36 51	55 5	69 35
i. xi.	11 51	iii. ix.	38 04	v. vii.	71 06
5 55	12 51	5 55	39 17	5 55	72 39
10 50	13 52	10 50	40 31	10 50	74 12
15 45	14 53	15 45	41 45	15 45	75 45
20 40	15 54	20 40	43 01	20 40	77 20
25 35	16 56	25 35	44 18	25 35	78 35
30 30	17 58	30 30	45 35	30 30	80 27
35 25	19 00	35 25	46 55	35 25	82 02
40 20	20 04	40 20	48 12	40 20	83 36
45 15	21 07	45 15	49 31	45 15	85 13
50 10	22 11	50 10	50 52	50 10	86 49
55 5	23 12	55 5	52 13	55 5	88 24
				vi. vi.	90 00

B. The above 2nd. Column gives the true Distances of each 5 min. from 0.59 to 11.51 therefore trust to the rest.

A Table shewing what Angle every Hour Quarters, Halfe, and Three Quarters of an Hour, makes in a Direct South Dial.

A Table for East and West Dials.

A Table shewing what Angle every Hour, Quarters, Halfe, and Three Quarters of an Hour makes in a Polar Dial.

Hours.	d.	m.
xii.	00	00
1	3	21
2	2	41
3	1	7
i.	xi.	9
1	3	11
2	2	14
3	1	17
ii.	x.	19
1	3	22
2	2	25
3	1	28
iii.	ix.	31
1	3	35
2	2	39
3	1	42
iiii.	viii.	47
1	3	51
2	2	56
3	1	61
v.	vii.	66
1	3	72
2	2	78
3	1	83
vi.		90

Hours.	d.	m.
vi.	00	00
1	3	03
2	2	07
3	1	11
vii.	v.	15
1	3	18
2	2	22
3	1	26
viii.	iiii.	30
1	3	33
2	2	37
3	1	41
ix.	iii.	45
1	3	48
2	2	52
3	1	56
x.	ii.	60
1	3	63
2	2	67
3	1	72
xi.	i.	75

Hours.	d.	m.
xii.	00	00
1	3	03
2	2	07
3	1	11
i.	xi.	15
1	3	18
2	2	22
3	1	26
ii.	x.	30
1	3	33
2	2	37
3	1	41
iii.	ix.	45
1	3	48
2	2	52
3	1	56
iiii.	viii.	60
1	3	63
2	2	67
3	1	72
v.	vii.	75
1	3	78
2	2	82
3	1	86
vi.		90

A TABLE of *Hour-Distances*, and Parts of an *Hour* from the *Substile*, in *Declining Dials*, in the Latitude 51 deg. 30 min.

South Declin- ing. 01. 00			South Declin- ing 02. 00			South Declin- ing. 03. 00		
Hours	D.	M.	Hours	D.	M.	Hours	D.	M.
vi	93	28	vi	94	06	vi	96	06
1 3	86	02	1 3	86	28	1 3	90	06
2 2	80	04	2 2	80	24	2 2	84	05
3 1	74	14	3 1	76	11	3 1	78	09
vii v	68	35	vii v	70	27	vii v	72	21
1 3	63	11	1 3	64	58	1 3	66	47
2 2	58	02	2 2	59	44	2 2	61	28
3 1	53	11	3 1	54	47	3 1	56	24
viii iii	48	38	viii iii	50	08	viii iii	52	18
1 3	44	22	1 3	45	46	1 3	47	11
2 2	39	41	2 2	41	40	2 2	43	00
3 1	36	47	3 1	37	50	3 1	39	04
ix iii	33	03	ix iii	34	13	ix iii	35	25
1 3	28	52	1 3	30	49	1 3	31	56
2 2	25	44	2 2	27	36	2 2	28	39
3 1	22	48	3 1	24	33	3 1	25	33
x ii	20	43	x ii	21	39	x ii	22	36
1 3	17	59	1 3	18	42	1 3	19	48
2 2	15	20	2 2	16	13	2 2	17	05
3 1	12	47	3 1	13	38	3 1	14	29
xi i	10	18	xi i	10	38	xi i	11	57
1 3	07	52	1 3	08	42	1 3	09	30
2 2	05	29	2 2	06	18	2 2	07	05
3 1	03	09	3 1	03	55	3 1	04	43
xii	00	48	xii	01	36	xii	02	23
Sub- stile			Sub- stile			Sub- stile		
1 3	01	52	1 3	00	55	1 3	00	03
2 2	03	53	2 2	03	05	2 2	02	18
3 1	06	14	3 1	05	26	3 1	04	38

(1)				(2)				(3)			
i	xi	08	38	i	xi	07	49	i	xi	07	00
I	3	11	04	I	3	10	15	I	3	09	25
2	2	13	30	2	2	12	43	2	2	11	52
3	1	16	10	3	1	15	16	3	1	14	24
ii	x	18	50	ii	x	17	45	ii	x	17	00
I	3	21	36	I	3	20	39	I	3	19	41
2	2	24	30	2	2	23	30	2	2	22	30
3	1	28	05	3	1	27	01	3	1	25	27
iii	ix	30	45	iii	ix	29	39	iii	ix	28	32
I	3	34	09	I	3	33	00	I	3	31	48
2	2	37	45	2	2	36	32	2	2	35	16
3	1	41	46	3	1	40	15	3	1	38	56
iiii	viii	45	41	iiii	viii	44	17	iiii	viii	42	52
I	3	50	07	I	3	48	33	I	3	47	02
2	2	54	04	2	2	53	05	2	2	51	30
3	1	59	58	3	1	57	55	3	1	56	14
v	vii	64	51	v	vii	63	03	v	vii	61	16
I	3	70	21	I	3	68	27	I	3	66	38
2	2	76	04	2	2	74	06	2	2	72	09
3	1	81	55	3	1	79	57	3	1	77	56
vi		87	56	vi		85	54	vi		83	53

South Declin- ing. 04 00				South Declin- ing. 05 00				South Declin- ing. 06 00			
Hours	D.	M.		Hours	D.	M.		Hours	D.	M.	
vi		99	12	2	2	88	13	2	2	90	15
I	3	92	12	3	1	82	11	3	1	84	12
2	2	86	11	vii	v	76	17	vii	v	78	14
3	1	80	11	I	3	70	32	I	3	72	25
vii	v	74	19	2	2	65	01	2	2	66	49
I	3	68	40	3	1	59	47	3	1	61	28
2	2	63	35	viii	iiii	54	49	viii	iiii	56	25
3	1	58	06	I	3	50	10	I	3	51	39
viii	iiii	53	14	2	2	45	44	2	2	47	10
I	3	48	40	3	1	41	40	3	1	42	49
2	2	44	24	ix	iii	37	50	ix	iii	39	03
3	1	40	23	I	3	34	13	I	3	35	32

	(4)				(5)				(6)			
00	ix	iii	36	37	2	2	30	49	2	2	31	54
25	1	3	33	40	3	1	27	36	3	1	28	38
52	2	2	29	44	x	ii	24	33	x	ii	25	22
24	3	1	26	35	1	3	21	39	1	3	22	35
00	x	ii	23	35	2	2	18	53	2	2	19	47
41	1	3	20	45	3	1	16	13	3	1	17	05
30	2	2	18	00	xi	i	13	39	xi	i	14	30
27	3	1	15	21	1	3	11	09	1	3	11	58
32	xi	i	12	49	2	2	08	49	2	2	09	31
48	1	3	10	20	3	1	06	23	3	1	07	07
16	2	2	07	55	xii		03	50	xii		04	45
56	3	1	05	52	1	3	01	38	1	3	02	25
52	xii		03	11	Sub-	stile			2	2	00	06
02	1	3	00	51	2	2	00	53	Sub-	stile		
30	Sub-	stile			3	1	03	01	3	1	02	14
14	2	2	01	29	1	xi	05	23	1	xi	04	34
16	3	1	03	49	1	3	07	45	1	3	06	56
38	i	xi	06	11	2	2	10	10	2	2	09	20
09	1	3	08	34	3	1	12	38	3	1	11	46
56	2	2	10	43	ii	x	15	10	ii	x	14	17
53	3	1	13	30	1	3	17	48	1	3	16	52
n-	ii	x	16	04	2	2	20	32	2	2	19	34
00	1	3	18	44	3	1	23	22	3	1	22	22
M.	2	2	20	45	iii	ix	26	21	iii	ix	25	17
15	3	1	23	36	1	3	29	30	1	3	28	22
12	iii	ix	27	26	2	2	32	49	2	2	31	37
14	1	3	30	38	3	1	36	20	3	1	35	04
25	2	2	34	01	iiii	viii	39	05	iiii	viii	38	52
49	3	1	37	37	1	3	44	05	1	3	42	39
28	iiii	viii	41	26	2	2	48	21	2	2	46	49
25	1	3	45	31	3	1	52	54	3	1	51	16
39	2	2	48	42	v	vii	57	44	v	vii	56	01
10	3	1	53	16	1	3	62	52	1	3	61	03
49	v	vii	59	28	2	2	68	16	2	2	66	23
03	1	3	64	41	3	1	73	57	3	1	71	58
32	2	2	70	11	vi		79	46	vi		77	46
22	3	1	75	53	1	3	85	45	1	3	83	43
	vi		81	48								

South Declin- ing. 07 00				South Declin- ing. 08 00				South Declin- ing. 09 00			
Hours		D.	M.	Hours		D.	M.	Hours		D.	M.
2	2	92	18	2	2	94	26	2	2	96	16
3	1	86	14	3	1	88	17	3	1	90	23
vii	v	80	13	vii	v	82	13	vii	v	84	15
1	3	74	21	1	3	77	52	1	3	78	14
2	2	68	38	2	2	70	32	2	2	72	23
3	1	63	12	3	1	64	58	3	1	66	45
viii	iii	58	02	viii	iii	59	42	viii	iii	61	23
1	3	53	10	1	3	54	45	1	3	56	18
2	2	48	35	2	2	50	04	2	2	51	31
3	1	44	18	3	1	45	40	3	1	47	02
ix	iii	39	17	ix	iii	41	34	ix	iii	42	50
1	3	36	30	1	3	38	44	1	3	38	52
2	2	32	59	2	2	34	07	2	2	35	14
3	1	29	39	3	1	30	43	3	1	31	46
x	ii	26	30	x	ii	27	30	x	ii	28	24
1	3	23	32	1	3	24	49	1	3	25	25
2	2	20	40	2	2	21	36	2	2	22	29
3	1	17	57	3	1	18	49	3	1	19	41
xi	i	15	19	xi	i	16	10	xi	i	17	10
1	3	12	47	1	3	13	56	1	3	14	26
2	2	10	20	2	2	11	07	2	2	11	6
3	1	07	54	3	1	08	42	3	1	09	21
xii		05	32	xii		06	19	xii		07	05
1	3	02	42	1	3	03	59	1	3	04	45
2	2	00	53	2	2	01	40	2	2	02	26
Sub.		file		Sub.		file		3	1	00	07
3	1	01	29	3	1	00	39	Sub.		file.	
1	xi	03	36	1	xi	02	59	i	xi	02	11
1	3	06	06	1	3	05	19	1	3	04	30
2	2	08	30	2	2	07	40	2	2	06	51
3	1	10	55	3	1	10	04	3	1	09	13
ii	x	13	24	ii	x	12	33	ii	x	11	40
1	3	15	28	1	3	15	03	1	3	14	09
2	2	18	36	2	2	17	40	2	2	16	44
3	1	21	22	3	1	20	22	3	1	19	24

(7)

iii	ix	24	19
I	3	27	16
2	2	30	28
3	I	33	50
iiii	viii	37	26
I	3	41	16
2	2	45	20
3	I	49	21
v	vii	54	20
I	3	59	16
2	2	64	30
3	I	70	01
vi		75	45
I	3	81	40

(8)

iii	ix	23	13
I	3	26	11
2	2	29	19
3	I	32	37
iiii	viii	36	08
I	3	39	52
2	2	43	52
3	I	48	08
v	vii	52	40
I	3	57	31
2	2	62	39
3	I	68	05
vi		73	46
I	3	79	38

(9)

iii	ix	22	08
I	3	25	09
2	2	28	10
3	I	31	25
iiii	viii	34	15
I	3	38	30
2	2	42	22
3	I	46	34
v	vii	51	04
I	3	56	47
2	2	60	50
3	I	66	10
vi		71	46
I	3	77	36

South Declin-
ing. 10 00

Hours	D.	M.
3	I	92 22
vii	v	86 15
I	3	80 12
2	2	74 16
3	I	68 32
viii	iiii	63 04
I	3	57 53
2	2	53 00
3	I	48 25
ix	iii	44 07
I	3	40 06
2	2	36 21
3	I	32 49
x	ii	29 28
I	3	26 22
2	2	23 24
3	I	20 34

South Declin-
ing. 11 00

Hours	D.	M.
3	I	94 25
vii	v	88 17
I	3	82 10
2	2	76 11
3	I	70 22
viii	iiii	64 48
I	3	59 30
2	2	54 30
3	I	49 49
ix	iii	45 25
I	3	41 19
2	2	37 59
3	I	33 53
x	ii	30 30
I	3	27 18
2	2	24 18
3	I	21 25

South Declin-
ing. 12 00

Hours	D.	M.
3	I	96 25
vii	v	90 20
I	3	84 01
2	2	78 03
3	I	72 10
viii	iiii	66 29
I	3	61 05
2	2	55 19
3	I	51 12
ix	iii	46 42
I	3	42 30
2	2	38 36
3	I	34 56
x	ii	31 28
I	3	28 14
2	2	25 11
3	I	22 6

(10)				(11)				(12)			
xi	i	17	51	xi	i	18	40	xi	i	19	29
1	3	15	14	1	3	16	03	1	3	16	08
2	2	12	43	2	2	13	30	2	2	14	16
3	1	10	16	3	1	11	03	3	1	11	47
xii		07	52	xii		08	38	xii		09	23
1	3	05	31	1	3	06	17	1	3	07	00
2	2	03	12	2	2	03	51	2	2	04	40
3	1	00	54	3	1	01	39	3	1	02	23
Sub-		file.		Sub-		file.		i	xi	00	16
i	xi	01	25	i	xi	00	38	Sub-		file.	
1	3	03	43	1	3	02	57	1	3	02	11
2	2	06	02	2	2	05	15	2	2	04	29
3	1	08	24	3	1	07	35	3	1	06	48
ii	x	10	48	ii	x	09	59	ii	x	09	09
1	3	13	17	1	3	12	42	1	3	11	34
2	2	15	49	2	2	14	55	2	2	14	03
3	1	18	27	3	1	17	30	3	1	16	36
iii	ix	21	12	iii	ix	20	17	iii	ix	19	04
1	3	24	03	1	3	23	01	1	3	22	00
2	2	27	03	2	2	25	58	2	2	24	54
3	1	30	14	3	1	29	05	3	1	27	57
iiii	viii	33	36	iiii	viii	32	23	iiii	viii	31	11
1	3	37	10	1	3	35	52	1	3	34	40
2	2	41	00	2	2	39	36	2	2	38	15
3	1	45	04	3	1	43	35	3	1	42	09
v	vii	49	26	v	vii	47	51	v	vii	46	20
1	3	54	04	1	3	52	37	1	3	50	49
2	2	59	02	2	2	57	16	2	2	55	33
3	1	64	17	3	1	62	16	3	1	60	37
vi		69	49	vi		67	52	vi		66	00
1	3	75	36	1	3	73	35	1	3	71	39
2	2	81	33	2	2	79	16	2	2	77	32

South Declin- ing. 13 00				South Declin- ing. 14 00				South Declin- ing. 15 00			
Hours	D.	M.		Hours	D.	M.		Hours	D.	M.	
3 I	96	43		vii v	94	25		vii v	96	28	
vii v	90	43		I 3	88	13		I 3	91	16	
I 3	86	11		2 2	82	01		2 2	84	02	
2 2	80	04		3 I	75	58		3 I	77	54	
3 I	74	05		viii iiii	70	06		viii iiii	71	56	
viii iiii	68	08		I 3	64	29		I 3	66	12	
I 3	62	48		2 2	59	10		2 2	60	46	
2 2	57	35		3 I	54	09		3 I	55	38	
3 I	52	42		ix iiii	49	27		ix iiii	50	50	
ix iiii	48	04		I 3	45	02		I 3	46	21	
I 3	43	48		2 2	40	58		2 2	42	09	
2 2	39	48		3 I	37	08		3 I	38	14	
3 I	36	02		x ii	33	33		x ii	34	35	
x ii	32	32		I 3	30	11		I 3	31	09	
I 3	29	13		2 2	27	01		2 2	27	56	
2 2	26	06		3 I	24	02		3 I	24	53	
3 I	23	09		xi i	21	11		xi i	22	00	
xi i	20	21		I 3	18	51		I 3	19	15	
I 3	17	38		2 2	15	21		2 2	16	37	
2 2	15	04		3 I	13	20		3 I	14	16	
3 I	12	37		xii	10	54		xii	11	38	
xii	10	08		I 3	08	31		I 3	09	15	
I 3	07	47		2 2	06	11		2 2	06	55	
2 2	05	27		3 I	03	54		3 I	04	37	
3 I	03	09		i xi	01	36		i xi	02	21	
i xi	00	53		Sub- stile				Sub- stile			
Sub- stile				I 3	00	39		Sub- stile			
I 3	01	24		2 2	02	55		2 2	02	10	
2 2	03	41		3 I	05	12		3 I	04	26	
3 I	06	00		ii x	07	31		ii x	06	43	
ii x	08	20		I 3	09	53		I 3	09	04	
I 3	10	42		2 2	12	18		2 2	11	27	
2 2	13	45		3 I	14	47		3 I	13	45	
3 I	15	40		iii ix	17	20		iii ix	16	25	

(13)				(14)				(15)			
iii	ix	18	16	I	3	19	18	I	3	19	02
I	3	21	00	2	2	22	01	2	2	21	47
2	2	23	50	3	I	24	56	3	I	24	36
3	I	26	49	iiii	viii	28	50	iiii	viii	27	41
iiii	viii	30	00	I	3	32	06	I	3	30	53
I	3	33	20	2	2	35	35	2	2	34	18
2	2	36	54	3	I	39	19	3	I	37	56
3	I	40	43	V	vii	43	18	V	vii	41	41
V	vii	44	43	I	3	47	34	I	3	45	58
I	3	49	09	2	2	52	07	2	2	50	28
2	2	53	49	3	I	57	00	3	I	55	14
3	I	58	47	vi		62	11	vi		60	21
vi		64	04	I	3	67	42	I	3	65	46
I	3	69	39	2	2	73	28	2	2	71	28
2	2	77	04	3	I	77	50	3	I	77	24

South Declin- ing. 16 00				South Declin- ing. 17 00				South Declin- ing. 18 00			
Hours		D.	M.	Hours		D.	M.	Hours		D.	M.
vii	v	98	31	vii	v	100	33	vii	v	102	38
I	3	92	17	I	3	94	20	I	3	96	32
2	2	86	01	2	2	88	02	2	2	90	05
3	I	79	49	3	I	81	37	3	I	83	46
viii	iii	73	45	viii	iii	75	38	viii	iii	77	32
3	3	67	55	I	3	69	42	I	3	71	30
2	2	62	21	2	2	64	02	2	2	65	43
I	I	57	07	3	I	58	40	3	I	60	14
ix	iii	52	41	ix	iii	53	58	ix	iii	55	04
I	3	47	36	I	3	48	56	I	3	50	16
2	2	43	18	2	2	44	33	2	2	45	46
3	I	39	19	3	I	40	24	3	I	41	36
x	ii	35	35	x	ii	36	39	x	ii	37	42
I	3	32	05	I	3	32	29	I	3	34	04
2	2	28	29	2	2	29	45	2	2	30	44
3	I	25	43	3	I	26	37	3	I	27	29

(16)

(17)

(18)

01	xi	i	22	48	xi	i	23	36	xi	i	24	28
47	1	3	20	01	1	3	20	50	1	3	21	38
36	2	2	17	22	2	2	17	45	2	2	18	54
41	3	1	14	49	3	1	15	35	3	1	16	18
53	xii		12	22	xii		13	05	xii		13	49
18	1	3	09	57	1	3	10	41	1	3	11	24
56	2	2	07	37	2	2	08	21	2	2	09	02
41	3	1	05	14	3	1	06	05	3	1	06	44
58	i	xi	03	04	i	xi	03	37	i	xi	04	29
28	1	3	00	49	1	3	01	32	1	3	02	16
14	Sub-	ftile.			Sub-	ftile.			2	2	00	02
21	2	2	01	26	2	2	00	53	Sub-	ftile.		
46	3	1	03	40	3	1	02	56	3	1	02	12
28	ii	x	05	57	ii	x	05	11	ii	x	04	25
24	1	3	08	15	1	3	07	28	1	3	06	12
7-	2	2	10	36	2	2	09	47	2	2	08	59
00	3	1	13	00	3	1	12	10	3	1	11	20
	iii	ix	15	30	iii	ix	14	37	iii	ix	13	45
M.	1	3	18	05	1	3	17	09	1	3	16	14
	2	2	20	47	2	2	19	49	2	2	18	50
	3	1	23	34	3	1	22	54	3	1	21	33
38	iii	viii	26	33	iii	viii	25	28	iii	viii	24	24
32	1	3	29	41	1	3	28	33	1	3	27	24
05	2	2	33	01	2	2	31	48	2	2	30	35
46	3	1	36	34	3	1	35	54	3	1	33	58
32	v	vii	40	22	v	vii	38	59	v	vii	37	36
30	1	3	44	26	1	3	42	58	1	3	41	29
43	2	2	48	48	2	2	47	53	2	2	45	40
14	3	1	53	30	3	1	51	49	3	1	50	01
04	vi		58	30	vi		56	44	vi		54	58
16	1	3	63	50	1	3	61	58	1	3	60	06
46	2	2	69	28	2	2	67	32	2	2	65	34
36	3	1	75	23	3	1	73	20	3	1	71	21

South Declin- ing. 19 00				South Declin- ing. 20 00				South Declin- ing. 21 00			
Hours		D. M.		Hours		D. M.		Hours		D. M.	
1	3	98	28	1	3	100	31	1	3	102	39
2	2	92	07	2	2	96	16	2	2	96	14
3	1	85	44	3	1	87	47	3	1	89	48
viii	iiii	79	28	viii	iiii	81	25	viii	iiii	83	22
1	3	73	19	1	3	75	11	1	3	77	02
2	2	67	26	2	2	69	10	2	2	70	55
3	1	61	50	3	1	63	27	3	1	65	04
ix	iii	56	32	ix	iii	57	21	ix	iii	59	32
1	3	51	37	1	3	53	00	1	3	54	32
2	2	47	00	2	2	48	16	2	2	49	31
3	1	42	44	3	1	43	45	3	1	45	02
x	ii	38	45	x	ii	39	50	x	ii	40	53
1	3	35	02	1	3	36	02	1	3	37	01
2	2	31	35	2	2	32	32	2	2	33	25
3	1	28	20	3	1	29	12	3	1	30	03
xi	i	25	17	xi	i	26	06	xi	i	26	51
1	3	22	23	1	3	23	10	1	3	23	56
2	2	19	39	2	2	20	24	2	2	21	08
3	1	17	02	3	1	17	45	3	1	18	28
xii		14	31	xii		15	13	xii		15	54
1	3	12	06	1	3	12	47	1	3	13	26
2	2	09	44	2	2	13	25	2	2	11	04
3	1	07	26	3	1	08	07	3	1	08	23
i	xi	05	11	i	xi	05	52	i	xi	06	32
1	3	02	59	3	1	03	37	1	3	04	18
2	2	00	44	2	2	01	26	2	2	02	27
Sub-		stile		Sub-		stile		Sub-		stile.	
3	1	01	28	3	1	00	46	3	1	00	04
ii	x	03	41	ii	x	02	58	ii	x	02	14
1	3	05	56	1	3	05	10	1	3	04	27
2	2	08	12	2	2	07	25	2	2	06	40
3	1	10	31	3	1	09	43	3	1	08	55
iii	ix	12	53	iii	ix	12	03	iii	ix	11	13
1	3	15	41	1	3	14	28	1	3	13	36

(19)				(20)				(21)			
2	2	17	54	2	2	16	58	2	2	16	05
3	1	20	33	3	1	19	35	3	1	18	37
iiii	viii	23	20	iiii	viii	22	19	iiii	viii	21	18
1	3	26	41	1	3	25	11	1	3	24	07
2	2	29	24	2	2	28	14	2	2	27	05
3	1	32	41	3	1	31	28	3	1	30	15
v	vii	36	15	v	vii	34	56	v	vii	33	38
1	3	40	03	1	3	38	38	1	3	37	14
2	2	44	07	2	2	42	37	2	2	41	08
3	1	48	30	3	1	46	54	3	1	45	18
vi		53	13	vi		51	30	vi		49	49
1	3	58	16	1	3	56	27	1	3	54	40
2	2	63	38	2	2	61	45	2	2	59	52
3	1	69	21	3	1	67	23	3	1	65	25
vii	v	75	21	vii	v	73	19	vii	v	71	17

South Declin- ing. 22 00				South Declin- ing. 23 00				South Declin- ing. 24 00			
Hours	D.	M.		Hours	D.	M.		Hours	D.	M.	
1	3	105	15	1	3	106	38	2	2	10	25
2	2	98	16	2	2	100	22	3	1	95	56
3	1	91	49	3	1	93	54	viii	iiii	89	21
viii	iiii	85	20	viii	iiii	87	21	1	3	82	47
1	3	78	56	1	3	80	52	2	2	76	20
2	2	72	42	2	2	74	31	3	1	70	07
3	1	66	45	3	1	68	25	ix	iii	64	12
ix	iii	61	04	ix	iii	62	38	1	3	58	38
1	3	55	46	1	3	57	13	2	2	53	26
2	2	50	49	2	2	52	08	3	1	48	37
3	1	46	14	3	1	47	25	x	ii	44	08
x	ii	41	58	x	ii	43	03	1	3	39	49
1	3	38	01	1	3	39	00	2	2	36	11
2	2	34	20	2	2	35	16	3	1	32	37
3	1	30	55	3	1	31	46	xi	i	29	19

(22)				(23)				(24)			
xi	i	27	43	xi	i	28	31	i	3	26	12
I	3	24	42	I	3	25	28	2	2	23	17
2	2	21	52	2	2	22	35	3	I	20	32
3	I	19	10	3	I	19	51	xii		17	55
xii		16	36	xii		17	16	I	3	15	25
I	3	14	7	I	3	14	47	2	2	13	02
2	2	11	44	2	2	12	23	3	I	10	42
3	I	9	26	3	I	10	4	i	xi	08	27
i	xi	7	10	i	xi	7	49	I	3	06	15
I	3	4	57	I	3	5	37	2	2	04	04
2	2	2	46	2	2	3	26	3	I	01	53
3	I	0	36	3	I	I	16	Sub-	file		
Sub-	file			Sub-	file			ii	x	00	13
ii	x	I	34	ii	x	0	52	I	3	02	20
I	3	3	38	I	3	3	I	2	2	04	30
2	2	5	56	2	2	5	9	3	I	06	40
3	I	8	10	3	I	7	26	iii	ix	08	54
iii	ix	10	26	iii	ix	9	39	I	3	11	09
I	3	12	47	I	3	11	57	2	2	13	29
2	2	15	12	2	2	14	23	3	I	15	54
3	I	17	43	3	I	16	47	iii	viii	18	25
iii	viii	20	19	iii	viii	19	21	I	3	21	04
I	3	23	6	I	3	22	3	2	2	23	51
2	2	26	0	2	2	24	52	3	I	26	48
3	I	29	6	3	I	27	55	v	vii	29	54
v	vii	32	24	v	vii	31	8	I	3	33	18
I	3	35	53	I	3	34	34	2	2	36	54
2	2	39	43	2	2	38	17	3	I	40	47
3	I	43	48	3	I	42	15	vi		44	59
vi		48	12	vi		46	33	I	3	49	31
I	3	52	57	I	3	51	12	2	2	54	25
2	2	58	3	2	2	56	12	3	I	59	07
3	I	63	31	3	I	61	34	vii	v	65	20
vii	v	69	18	vii	v	67	18	I	3	71	19

South Declin- ing. 25. 00				South Declin- ing 26. 00				South Declin- ing. 27. 00			
Hours		D. M.		Hours		D. M.		Hours		D. M.	
2	2	103	28	2	1	106	33	2	2	108	35
3	1	98	00	3	2	100	06	3	1	102	10
viii	iiii	91	47	viii	iiii	94	21	viii	iiii	95	31
1	3	84	45	1	3	86	45	1	3	88	46
2	2	78	13	2	2	81	53	2	2	82	02
3	1	71	53	3	1	73	43	3	1	75	28
ix	iii	65	49	ix	iii	67	27	ix	iii	69	09
1	3	60	07	1	3	62	10	1	3	63	10
2	2	54	48	2	2	56	08	2	2	57	33
3	1	49	51	3	1	51	04	3	1	52	20
x	ii	45	16	x	ii	46	22	x	ii	47	31
1	3	41	02	1	3	42	02	1	3	42	50
2	2	37	08	2	2	38	02	2	2	38	58
3	1	33	30	3	1	34	19	3	1	35	12
xi	i	30	07	xi	i	30	53	xi	i	31	41
1	3	26	58	1	3	27	43	1	3	28	27
2	2	24	00	2	2	24	42	2	2	25	24
3	1	21	16	3	1	21	53	3	1	22	28
xii		18	35	xii		19	13	xii		19	51
1	3	16	04	1	3	16	02	1	3	16	39
2	2	13	39	2	2	13	37	2	2	14	14
3	1	11	20	3	1	11	19	3	1	12	31
i	xi	09	04	i	xi	09	40	i	xi	10	16
1	3	06	52	1	3	07	38	1	3	08	03
2	2	04	42	2	2	05	19	2	2	05	55
3	1	02	34	3	1	03	11	3	1	03	47
ii	x	00	02	ii	x	01	05	ii	x	01	40
Sub-	stile			Sub-	stile			Sub-	stile		
1	3	01	40	1	3	01	01	1	3	00	23
2	2	03	47	2	2	02	33	2	2	02	28
3	1	05	58	3	1	05	15	3	1	04	34
iii	ix	08	08	iii	ix	07	24	iii	ix	06	42
1	3	10	22	1	3	09	35	1	3	08	51
2	2	12	41	2	2	11	51	2	2	11	09
3	1	15	03	3	1	14	11	3	1	13	22

(25)				(26)				(27)			
iiii viii	17	31		iiii viii	16	36		iiii viii	15	46	
i 3	20	32		i 3	19	08		i 3	18	13	
2 2	22	44		2 2	21	47		2 2	20	30	
3 1	25	47		3 1	24	36		3 1	23	34	
v vii	28	47		v vii	27	36		v vii	26	29	
i 3	32	03		i 3	30	47		i 3	29	36	
2 2	35	34		2 2	34	13		2 2	32	57	
3 1	39	29		3 1	37	54		3 1	36	32	
vi	43	28		vi	41	54		vi	40	26	
i 3	47	54		i 3	47	26		i 3	45	50	
2 2	52	41		2 2	52	13		2 2	50	31	
3 1	57	51		3 1	57	24		3 1	54	11	
vii v	63	24		vii v	61	26		vii v	59	33	
i 3	69	18		i 3	67	16		i 3	65	19	

South Declin- ing. 28 00				South Declin- ing. 29 00				South Declin- ing. 30 00			
Hours	D.	M.		Hours	D.	M.		Hours	D.	M.	
3 1	104	15		3 1	106	21		3 1	108	25	
viii iii	97	36		viii iii	99	42		viii iii	101	47	
i 3	91	20		i 3	92	17		i 3	94	55	
2 2	84	01		2 2	86	00		2 2	88	00	
3 1	77	19		3 1	79	12		3 1	81	05	
ix iii	70	52		ix iii	72	36		ix iii	74	21	
i 3	64	43		i 3	66	18		i 3	67	55	
2 2	58	58		2 2	60	24		2 2	61	52	
3 1	53	37		3 1	54	54		3 1	56	16	
x ii	48	40		x ii	49	50		x ii	51	00	
i 3	44	07		i 3	45	09		i 3	46	12	
2 2	39	56		2 2	40	52		2 2	41	48	
3 1	36	04		3 1	36	55		3 1	37	46	
xi i	32	26		xi i	33	16		xi i	34	02	
i 3	29	10		i 3	29	50		i 3	30	37	
2 2	26	06		2 2	26	38		2 2	27	26	
3 1	23	12		3 1	23	50		3 1	24	27	

(28)

(29)

(30)

(28)				(29)				(30)			
xii	20	29		xii	21	05		xii	21	40	
1 3	17	55		1 3	18	30		1 3	19	04	
2 2	15	27		2 2	15	59		2 2	16	35	
3 1	13	06		3 1	13	40		3 1	14	13	
xi 10	51			1 xi	11	24		1 xi	11	57	
1 3	08	38		1 3	09	12		1 3	09	44	
2 2	06	30		2 2	07	03		2 2	07	36	
3 1	04	04		3 1	04	58		3 1	05	32	
ii x	02	19		ii x	02	54		ii x	03	28	
1 3	00	15		1 3	00	54		1 3	01	26	
Sub- file.				Sub- file.				Sub- file.			
2 2	01	49		2 2	01	11		2 2	00	35	
3 1	03	54		3 1	03	14		3 1	02	37	
iii ix	06	00		iii ix	05	18		iii ix	04	39	
1 3	08	08		1 3	07	25		1 3	06	43	
2 2	10	18		2 2	09	34		2 2	08	50	
3 1	12	33		3 1	11	46		3 1	11	00	
iii viii	14	53		iii viii	14	03		iii viii	13	14	
1 3	17	18		1 3	16	25		1 3	15	34	
2 2	19	51		2 2	18	54		2 2	18	00	
3 1	22	33		3 1	21	32		3 1	20	34	
vii 25	23			vii 24	18			vii 23	16		
1 3	28	25		1 3	27	16		1 3	26	09	
2 2	31	41		2 2	30	29		2 2	29	15	
3 1	35	11		3 1	33	51		3 1	32	34	
vi 38	58			vi 37	32			vi 36	09		
1 3	43	05		1 3	41	34		1 3	40	03	
2 2	47	31		2 2	45	54		2 2	44	18	
3 1	52	24		3 1	50	38		3 1	48	56	
ii v	57	39		vii v	55	47		vii v	53	58	
1 3	63	19		1 3	61	20		1 3	54	25	
2 2	69	22		2 2	67	19		2 2	65	19	

South Declin- ing. 31 00			South Declin- ing. 32 00			South Declin- ing. 33 00		
Hours	D.	M.	Hours	D.	M.	Hours	D.	M.
3 I	110	29	3 I	112	32	viii iiii	108	07
viii iiii	103	54	viii iiii	106	00	I 3	101	16
I 3	97	21	I 3	99	05	2 2	94	11
2 2	90	02	2 2	92	05	3 I	87	00
3 I	83	02	3 I	85	00	ix iiii	79	53
ix iiii	76	10	ix iiii	78	00	I 3	73	00
I 3	69	35	I 3	71	16	2 2	66	27
2 2	63	22	2 2	64	53	3 I	60	19
3 I	57	34	3 I	58	55	x ii	54	39
x ii	52	12	x ii	53	25	I 3	49	27
I 3	47	17	I 3	48	21	2 2	44	42
2 2	42	46	2 2	43	43	3 I	41	00
3 I	38	38	3 I	39	29	xi i	36	23
xi i	34	50	xi i	35	36	I 3	32	45
I 3	31	20	I 3	32	02	2 2	29	24
2 2	28	06	2 2	28	45	3 I	26	18
3 I	25	05	3 I	25	42	xii	23	25
xii	22	17	xii	22	51	I 3	20	43
I 3	19	38	I 3	20	11	2 2	18	16
2 2	17	08	2 2	17	40	3 I	15	47
3 I	14	45	3 I	15	16	i xi	13	30
i xi	12	28	i xi	12	59	I 3	11	18
I 3	10	17	I 3	10	48	2 2	09	09
2 2	08	09	2 2	08	39	3 I	07	06
3 I	06	04	3 I	06	35	ii x	05	05
ii x	04	02	ii x	04	34	I 3	03	11
I 3	02	01	I 3	02	34	2 2	02	08
2 2	00	01	2 2	00	35	Sub- stile.		
Sub- stile			Sub- stile			3 I	00	49
3 I	02	00	I 3	01	24	iii ix	02	47
iii ix	04	01	iii ix	03	24	I 3	04	46
I 3	06	03	I 3	05	24	2 2	06	46
2 2	08	08	2 2	07	27	3 I	08	50
3 I	10	15	3 I	09	32	iii viii	10	57

(31)				(32)				(33)			
iiii	viii	12	28	iiii	viii	11	41	I	3	13	08
I	3	14	44	I	3	13	55	2	2	15	18
2	2	17	07	2	2	16	15	3	I	17	47
3	I	19	37	3	I	18	41	V	vii	20	19
V	vii	22	15	V	vii	21	15	I	3	22	58
I	3	25	04	I	3	22	00	2	2	25	40
2	2	28	04	2	2	26	56	3	I	28	52
3	I	31	18	3	I	30	04	vi		32	11
vi		34	48	vi		33	29	I	3	35	46
I	3	38	36	I	3	38	19	2	2	39	40
2	2	42	43	2	2	41	12	3	I	43	57
3	I	47	15	3	I	45	35	Vii	V	48	38
vii	V	52	09	vii	V	50	24	I	3	53	09
I	3	57	31	I	3	55	38	2	2	59	21
2	2	63	19	2	2	61	10	3	I	65	25

South Declin- ing. 34 00				South Declin- ing. 35 00				South Declin- ing. 36 00			
Hours	D.	M.		Hours	D.	M.		Hours	D.	M.	
viii	iiii	110	14	viii	iiii	112	18	viii	iiii	114	22
I	3	103	25	I	3	105	27	I	3	107	40
2	2	96	19	2	2	98	25	2	2	100	34
3	I	89	04	3	I	91	17	3	I	93	12
ix	iii	81	50	ix	iii	83	47	ix	iii	85	46
I	3	74	48	I	3	76	37	I	3	78	26
2	2	68	04	2	2	69	42	2	2	71	21
3	I	61	46	3	I	63	14	3	I	64	41
x	ii	55	56	x	ii	57	13	x	ii	58	32
I	3	50	35	I	3	51	42	I	3	52	51
2	2	45	42	2	2	46	41	2	2	47	39
3	I	41	14	3	I	42	07	3	I	43	00
xi	i	37	10	xi	i	37	57	xi	i	38	43
I	3	33	28	I	3	34	09	I	3	34	50
2	2	30	03	2	2	30	41	2	2	31	18
I	I	26	54	3	I	27	29	3	I	28	03
xii		23	59	xii		24	31	xii		25	04

(34)				(35)				(36)			
1	3	21	16	1	3	21	46	1	3	22	16
2	2	18	42	2	2	19	12	2	2	19	40
3	1	16	17	3	1	16	46	3	1	17	13
i	xi	14	00	i	xi	14	24	i	xi	14	54
1	3	11	47	1	3	12	15	1	3	12	42
2	2	09	40	2	2	10	08	2	2	10	35
3	1	07	36	3	1	08	05	3	1	08	32
ii	x	05	36	ii	x	06	06	ii	x	06	33
1	3	03	38	1	3	04	08	1	3	04	37
2	2	01	41	2	2	02	19	2	2	02	42
Sub-		ftile		3	1	00	18	3	1	00	49
3	1	00	15	Sub-		ftile		Sub-		ftile	
iii	ix	02	11	iii	ix	01	37	iii	ix	01	05
1	3	04	09	1	3	03	34	1	3	02	58
2	2	06	07	2	2	05	30	2	2	04	53
3	1	08	08	3	1	07	29	3	1	06	50
iii	viii	10	12	iii	viii	09	31	iii	viii	08	49
1	3	12	21	1	3	11	36	1	3	10	52
2	2	14	34	2	2	13	47	2	2	13	00
3	1	16	54	3	1	16	04	3	1	15	13
v	vii	19	21	v	vii	18	27	v	vii	17	33
1	3	21	57	1	3	20	58	1	3	20	00
2	2	24	43	2	2	23	40	2	2	22	38
3	1	27	10	3	1	26	34	3	1	25	27
vi		30	54	vi		29	41	vi		28	29
1	3	33	57	1	3	33	04	1	3	31	46
2	2	38	11	2	2	36	46	2	2	35	21
3	1	42	20	3	1	40	49	3	1	39	17
vii	v	46	55	vii	v	45	15	vii	v	43	36
1	3	51	55	1	3	50	18	1	3	48	22
2	2	57	24	2	2	55	30	2	2	53	36
3	1	64	19	3	1	61	21	3	1	59	21

South Declin- ing. 37 00				South Declin- ing. 38 00				South Declin- ing. 39 00			
Hours		D.	M.	Hours		D.	M.	Hours		D.	M.
1	3	109	41	1	3	112	01	1	3	114	29
2	2	102	45	2	2	104	57	2	2	107	08
3	1	95	21	3	1	97	33	3	1	99	43
ix	iii	87	49	ix	iii	89	56	ix	iii	91	52
1	3	80	21	1	3	82	20	1	3	84	18
2	2	73	06	2	2	74	55	2	2	76	43
3	1	66	15	3	1	67	52	3	1	69	28
x	ii	59	53	x	ii	61	17	x	ii	62	42
1	3	54	02	1	3	55	15	1	3	56	29
2	2	48	42	2	2	49	46	2	2	50	44
3	1	43	52	3	1	44	49	3	1	45	28
xi	i	39	30	xi	i	40	18	xi	i	41	06
1	3	35	32	1	3	36	15	1	3	36	56
2	2	31	55	2	2	32	33	2	2	33	09
3	1	28	37	3	1	29	11	3	1	29	44
xii		25	35	xii		26	04	xii		26	35
1	3	22	29	1	3	23	15	1	3	23	43
2	2	20	08	2	2	20	36	2	2	21	03
3	1	17	40	3	1	18	07	3	1	18	31
i	xi	15	21	i	xi	15	47	i	xi	16	12
1	3	13	09	1	3	13	34	1	3	13	59
2	2	11	02	2	2	11	28	2	2	11	52
3	1	09	00	3	1	09	26	3	1	09	51
ii	x	07	01	ii	x	07	08	ii	x	07	53
1	3	05	05	1	3	05	34	1	3	05	58
2	2	03	12	2	2	03	41	2	2	04	00
3	1	01	20	3	1	01	50	3	1	02	18
Sub- iii	ix	00	32	Sub- iii	ix	00	01	Sub- iii	ix	00	28
1	3	02	24	1	3	01	52	1	3	01	20
2	2	04	17	2	2	03	53	2	2	03	10
3	1	06	13	3	1	05	35	3	1	05	00
iiii	viii	08	10	iiii	viii	07	30	iiii	viii	06	53
1	3	10	10	1	3	09	28	1	3	08	49

(37)				(38)				(39)			
2	2	12	14	2	2	11	00	2	2	10	48
3	I	14	24	3	I	13	37	3	I	12	52
V	vii	16	41	V	vii	15	51	V	vii	15	01
I	3	19	40	I	3	18	09	I	3	17	18
2	2	21	38	2	2	20	39	2	2	19	49
3	I	24	21	3	I	23	18	3	I	22	17
	vi	27	18		vi	26	09		vi	25	03
I	3	30	29	I	3	29	15	I	3	28	03
2	2	33	51	2	2	32	37	2	2	31	20
3	I	37	47	3	I	36	19	3	I	34	54
vii	V	42	00	vii	V	40	23	vii	V	38	51
I	3	46	36	I	3	44	53	I	3	43	14
2	2	51	43	2	2	49	52	2	2	48	05
3	I	57	21	3	I	55	21	3	I	53	27
viii	iii	63	30	viii	iii	61	24	viii	iii	59	22

South Declin- ing. 40 00			South Declin- ing. 41 00			South Declin- ing. 42 00		
Hours	D.	M.	Hours	D.	M.	Hours	D.	M.
I	3	116 16	2	2	111 31	2	2	113 45
2	2	111 57	3	I	104 09	3	I	106 17
3	I	101 56	ix	iii	96 22	ix	iii	98 02
ix	iii	94 16	I	3	88 15	I	3	90 31
I	3	86 20	2	2	79 18	2	2	82 28
2	2	78 35	3	I	72 38	3	I	74 37
3	I	71 10	x	ii	65 24	x	ii	67 12
x	ii	64 10	I	3	58 46	I	3	60 21
I	3	57 44	2	2	52 44	2	2	54 07
2	2	51 54	3	I	47 19	3	I	48 30
3	I	46 42	xi	i	42 27	xi	i	43 29
xi	i	41 53	I	3	38 06	I	3	37 52
I	3	37 37	2	2	34 10	2	2	34 58
2	2	33 46	3	I	30 36	3	I	31 19
3	I	30 16	xii		27 33	xii		28 01
xii		27 03	I	3	24 30	I	3	25 00

(40)

(41)

(42)

1	3	24	10	2	2	21	46	2	2	22	15
2	2	21	27	3	1	19	12	3	1	19	43
3	1	18	57	1	xi	16	53	1	xi	17	22
i	xi	16	36	1	3	14	37	1	3	15	03
1	3	14	22	2	2	12	35	2	2	12	59
2	2	12	16	3	1	10	34	3	1	10	59
3	1	10	14	ii	x	08	38	ii	x	09	02
ii	x	08	17	1	3	06	46	1	3	07	11
1	3	06	28	2	2	04	53	2	2	05	23
2	2	04	34	3	1	03	11	3	1	03	36
3	1	02	45	iii	ix	01	25	iii	ix	01	51
iii	ix	00	58	Sub- stle				1	3	00	03
Sub- stle				1	3	00	21	Sub- stle			
1	3	00	49	2	2	02	07	2	2	02	34
2	2	02	38	3	1	03	54	3	1	03	22
3	1	04	27	iii	viii	05	42	iii	viii	05	08
iii	viii	06	17	1	3	07	32	1	3	06	57
1	3	08	10	2	2	09	26	2	2	08	43
2	2	10	07	3	1	11	24	3	1	10	42
3	1	12	08	v	vii	13	27	v	vii	12	43
v	vii	14	14	1	3	15	37	1	3	14	49
1	3	16	27	2	2	17	53	2	2	17	01
2	2	18	46	3	1	20	19	3	1	19	23
3	1	21	17	vi		22	57	vi		21	54
vi		23	59	1	3	25	43	1	3	24	38
1	3	26	21	2	2	28	48	2	2	27	37
2	2	30	03	3	1	32	10	3	1	30	33
3	1	33	31	vii	v	35	52	vii	v	34	26
vii	v	37	21	1	3	39	58	1	3	38	25
1	3	41	35	2	2	44	33	2	2	42	51
2	2	46	18	3	1	49	38	3	1	47	49
3	1	51	33	viii	iiii	55	19	viii	iiii	53	20
viii	iiii	57	20	1	3	61	35	1	3	59	29

South Declin- ing. 43. 00				South Declin- ing 44. 00				South Declin- ing. 45. 00			
Hours		D.	M.	Hours		D.	M.	Hours		D.	M.
ix	iii	100	54	ix	iii	103	10	ix	iii	105	29
1	3	92	45	1	3	94	56	1	3	97	23
2	2	84	31	2	2	86	29	2	2	88	39
3	1	76	28	3	1	78	10	3	1	80	25
x	ii	68	48	x	ii	70	15	x	ii	72	27
1	3	61	36	1	3	62	58	1	3	64	27
2	2	55	10	2	2	56	15	2	2	57	29
3	1	49	30	3	1	50	15	3	1	51	30
xi	i	44	19	xi	i	44	58	xi	i	45	58
1	3	40	00	1	3	40	12	1	3	40	57
2	2	35	34	2	2	35	58	2	2	36	36
3	1	31	46	3	1	32	13	3	1	32	44
xii		28	29	xii		28	55	xii		29	21
1	3	25	27	1	3	25	40	1	3	26	02
2	2	22	40	2	2	22	52	2	2	23	29
3	1	20	00	3	1	20	17	3	1	20	44
i	xi	17	34	i	xi	17	51	i	xi	18	19
1	3	15	21	1	3	15	25	1	3	15	59
2	2	13	14	2	2	13	34	2	2	13	58
3	1	11	29	3	1	11	35	3	1	12	00
ii	x	09	25	ii	x	09	41	ii	x	10	03
1	3	07	35	1	3	07	56	1	3	08	18
2	2	05	54	2	2	06	18	2	2	06	30
3	1	04	36	3	1	04	30	3	1	04	47
iii	ix	02	17	iii	ix	02	40	iii	ix	02	26
1	3	00	34	1	3	01	08	1	3	01	25
Sub-	stile			Sub-	stile			Sub-	stile		
2	2	01	07	2	2	00	46	2	2	00	15
3	1	02	51	3	1	02	34	3	1	01	53
iiii	viii	04	38	iiii	viii	04	20	iiii	viii	03	34
1	3	06	24	1	3	06	00	1	3	05	15
2	2	08	15	2	2	07	40	2	2	06	59
3	1	10	04	3	1	09	28	3	1	08	30
v	vii	11	59	v	vii	11	20	v	vii	10	37
1	3	14	02	1	3	13	19	1	3	12	21

(43)

2	2	16	11
3	1	18	28
vi		20	55
1	3	23	32
2	2	26	24
3	1	29	32
vii	v	33	02
1	3	36	52
2	2	41	10
3	1	45	58
viii	iiii	51	22

(44)

2	2	15	19
3	1	17	37
vi		19	56
1	3	22	30
2	2	25	81
3	1	28	20
vii	v	31	38
1	3	35	26
2	2	39	33
3	1	44	14
viii	iiii	49	29

(45)

2	2	14	03
3	1	16	10
vi		19	01
1	3	21	28
2	2	24	09
3	1	27	05
vii	v	30	20
1	3	33	54
2	2	37	56
3	1	42	26
viii	iiii	47	31

South Declin-
ing. 46 00

Hours	D.	M.
3	1	116 39
ix	iii	117 50
1	3	99 34
2	2	90 58
3	1	82 20
x	ii	73 58
1	3	66 10
2	2	58 58
3	1	53 09
xi	i	46 49
1	3	41 41
2	2	37 18
3	1	33 19
xii		29 46
1	3	26 35
2	2	23 41
3	1	21 03
i	xi	18 37
1	3	16 21
2	2	14 15

South Declin-
ing. 47 00

Hours	D.	M.
1	3	117 57
ix	iii	109 00
1	3	101 51
2	2	93 21
3	1	84 25
x	ii	75 56
1	3	67 31
2	2	60 17
3	1	53 58
xi	i	47 39
1	3	42 23
2	2	37 51
3	1	33 50
xii		30 11
1	3	26 56
2	2	24 00
3	1	21 20
i	xi	18 52
1	3	16 39
2	2	14 32

South Declin-
ing. 48 00

Hours	D.	M.
1	3	117 06
ix	iii	112 36
1	3	104 21
2	2	95 35
3	1	86 35
x	ii	77 45
1	3	69 22
2	2	61 39
3	1	54 44
xi	i	48 36
1	3	43 19
2	2	38 28
3	1	34 18
xii		30 35
1	3	27 17
2	2	24 19
3	1	21 38
i	xi	19 09
1	3	16 53
2	2	14 47

(46)

3	I	12	15
ii	X	10	21
I	3	08	32
2	2	06	48
3	I	05	06
iii	ix	03	26
I	3	01	46
2	2	00	10
Sub-		file.	
3	I	01	27
iii	viii	03	05
I	3	04	48
2	2	06	25
3	I	08	10
V	vii	09	57
I	3	11	49
2	2	13	46
3	I	15	52
vi		18	06
I	3	20	29
2	2	23	05
3	I	25	55
vii	V	29	00
I	3	32	30
2	2	36	32
3	I	40	43
viii	iiii	45	38

(47)

3	I	12	29
ii	X	10	37
I	3	08	50
2	2	07	07
3	I	05	20
iii	ix	03	47
I	3	02	12
2	2	00	35
Sub-		file.	
3	I	01	01
iii	viii	02	30
I	3	04	11
2	2	05	52
3	I	07	31
V	vii	09	18
I	3	11	06
2	2	13	01
3	I	15	00
vi		17	11
I	3	19	27
2	2	20	00
3	I	24	44
vii	V	27	42
I	3	31	34
2	2	35	00
3	I	39	00
viii	iiii	43	54

(48)

3	I	12	47
ii	X	10	55
I	3	09	07
2	2	07	24
3	I	05	42
iii	ix	04	08
I	3	02	33
2	2	00	58
Sub-		file.	
3	I	00	36
iii	viii	02	09
I	3	03	45
2	2	05	21
3	I	06	59
V	vii	08	42
I	3	10	28
2	2	12	19
3	I	14	16
vi		16	21
I	3	18	35
2	2	21	00
3	I	23	38
vii	V	26	32
I	3	29	45
2	2	33	21
3	I	37	24
viii	iiii	41	54

South Declin-
ing. 49 00

Hours	D.	M.
ix	iii	115 10
I	3	107 46
2	2	97 50
3	I	88 53

South Declin-
ing. 50 00

Hours	D.	M.
ix	iii	117 22
I	3	109 14
2	2	91 08
3	I	81 48

South Declin-
ing. 51 00

Hours	D.	M.
ix	iii	118 00
I	3	111 43
2	2	112 52
3	I	93 27

(49)				(50)				(51)			
x	ii	79	43	x	ii	18	48	x	ii	83	55
i	3	71	04	i	3	72	49	i	3	74	27
2	2	63	02	2	2	64	30	2	2	65	59
3	1	55	47	3	1	57	02	3	1	58	14
xi	i	49	30	xi	i	50	25	xi	i	51	20
i	3	43	52	i	3	44	40	i	3	45	22
2	2	39	03	2	2	39	35	2	2	40	07
3	1	34	46	3	1	35	13	3	1	35	40
xii		30	58	xii		31	21	xii		31	45
i	3	27	36	i	3	27	55	i	3	28	13
2	2	24	36	2	2	24	52	2	2	25	03
3	1	21	54	3	1	22	07	3	1	22	18
xi		19	23	i	xi	19	36	i	xi	19	49
i	3	17	02	i	3	17	20	i	3	17	32
2	2	14	59	2	2	15	11	2	2	15	25
3	1	13	01	3	1	13	14	3	1	13	25
ii	x	11	13	ii	x	11	27	ii	x	11	36
i	3	09	20	i	3	09	46	i	3	09	57
2	2	07	40	2	2	07	57	2	2	08	12
3	1	06	21	3	1	06	27	3	1	06	41
iii	ix	04	30	iii	ix	04	54	iii	ix	04	59
i	3	02	53	i	3	03	12	i	3	03	30
2	2	01	19	2	2	01	41	2	2	01	59
Sub- file		3	1	Sub- file		00	10	Sub- file		00	35
i		00	15	Sub- file		01	19	Sub- file		00	58
iii viii		01	47	iii viii		02	50	iii viii		02	25
i	3	03	18	i	3	02	50	i	3	02	25
2	2	05	00	2	2	04	22	2	2	03	45
3	1	06	27	3	1	05	56	3	1	05	27
vii		08	00	v	vii	07	32	v	vii	07	00
i	3	09	49	i	3	09	12	i	3	08	36
2	2	11	37	2	2	10	57	2	2	10	18
3	1	13	32	3	1	12	47	3	1	12	05
vi		15	32	vi		15	03	vi		14	04
i	3	17	42	i	3	16	49	i	3	15	59
2	2	20	01	2	2	19	03	2	2	18	08
3	1	23	01	3	1	21	30	3	1	20	29
vii	v	25	37	vii	v	24	11	vii	v	23	02

(49)				(50)				(51)			
1	3	28	27	1	3	27	10	1	3	25	39
2	2	31	55	2	2	30	29	2	2	27	07
3	1	35	49	3	1	34	14	3	1	32	43
viii	iiii	40	11	viii	iiii	37	50	viii	iiii	36	56

South Declin- ing. 52 00				South Declin- ing. 53 00				South Declin- ing. 54 00			
Hours	D.	M.		Hours	D.	M.		Hours	D.	M.	
1	3	117	21	1	3	118	10	1	3	119	08
2	2	106	27	2	2	108	05	2	2	110	46
3	1	96	57	3	1	98	30	3	1	101	06
x	ii	86	09	x	ii	88	35	x	ii	90	46
1	3	76	27	1	3	78	29	1	3	80	40
2	2	67	29	2	2	69	30	2	2	71	00
3	1	59	22	3	1	60	40	3	1	62	05
xi	i	52	10	xi	i	55	20	xi	i	56	26
1	3	45	57	1	3	46	41	1	3	48	15
2	2	40	40	2	2	41	10	2	2	42	30
3	1	35	58	3	1	36	30	3	1	37	45
xii		32	05	xii		32	26	xii		32	46
1	3	28	24	1	3	28	39	1	3	28	56
2	2	25	13	2	2	25	25	2	2	25	40
3	1	22	24	3	1	22	36	3	1	22	50
1	xi	19	53	1	xi	20	12	1	xi	20	22
1	3	17	38	1	3	17	45	1	3	17	56
2	2	15	30	2	2	15	41	2	2	15	49
3	1	13	35	3	1	13	43	3	1	13	59
ii	x	11	48	ii	x	11	57	ii	x	12	06
1	3	10	00	1	3	10	08	1	3	10	21
2	2	08	21	2	2	08	38	2	2	08	43
3	1	06	44	3	1	07	00	3	1	07	10
iii	ix	05	18	iii	ix	05	31	iii	ix	05	44
1	3	03	47	1	3	04	10	1	3	04	15
2	2	02	18	2	2	02	35	2	2	02	52
3	1	00	52	3	1	01	11	3	1	01	30
Sub-4	file			Sub-5	file			iii viii	00	07	

(52)

iiii viii	00	34
I 3	02	00
2 2	03	28
3 1	04	46
v vii	06	28
I 3	08	03
2 2	09	40
3 1	11	23
vi	13	13
I 3	15	10
2 2	17	18
3 1	19	30
vii v	22	00
I 3	24	44
2 2	27	53
3 1	31	01
viii iii	35	34

(53)

iiii viii	00	12
I 3	01	36
2 2	03	02
3 1	04	32
v vii	05	56
I 3	07	27
2 2	09	03
3 1	10	46
vi	12	26
I 3	14	17
2 2	16	18
3 1	18	13
vii v	20	53
I 3	23	30
2 2	26	26
3 1	29	42
viii iii	33	33

(54)

Sub-	file
I 3	01 14
2 2	02 37
3 1	04 00
v vii	05 28
I 3	06 55
2 2	08 27
3 1	10 02
vi	11 46
I 3	13 35
2 2	15 30
3 1	17 36
vii v	19 50
I 3	22 23
2 2	25 13
3 1	18 20
viii iii	32 00

South Declin-
ing. 55. 00

Hours	D.	M.
I 3	126	02
2 2	113	20
3 1	103	44
x ii	93	24
I 3	82	55
2 2	72	47
3 1	63	30
xi i	55	25
I 3	48	21
2 2	42	22
3 1	37	18
xii	33	06
I 3	29	10
2 2	25	52

South Declin-
ing 56. 00

Hours	D.	M.
I 3	122	20
2 2	116	02
3 1	106	32
x ii	96	13
I 3	85	20
2 2	74	52
3 1	65	13
xi i	56	40
I 3	49	20
2 2	43	02
3 1	37	50
xii	33	24
I 3	29	21
2 2	26	01

South Declin-
ing. 57. 00

Hours	D.	M.
I 3	124	10
2 2	118	58
3 1	109	24
x ii	98	55
I 3	87	56
2 2	76	58
3 1	66	47
xi i	57	50
I 3	50	10
2 2	43	40
3 1	38	12
xii	33	42
I 3	29	28
2 2	26	15

(55)				(56)				(57)			
3	I	22	57	3	I	23	05	3	I	23	10
I	xi	20	23	I	xi	20	30	I	xi	20	33
I	3	18	04	I	3	18	10	I	3	18	16
2	2	15	56	2	2	16	03	2	2	16	09
3	I	14	00	3	I	14	10	3	I	14	15
ii	x	12	13	ii	x	12	17	ii	x	12	21
I	3	10	30	I	3	10	40	I	3	10	42
2	2	08	53	2	2	09	07	2	2	09	10
3	I	07	22	3	I	07	31	3	I	07	35
iii	ix	05	53	iii	ix	06	00	iii	ix	06	08
I	3	04	30	I	3	04	43	I	3	04	45
2	2	03	07	2	2	03	22	2	2	03	33
3	I	01	45	3	I	02	02	3	I	02	18
iii viii		00	26	iii viii		00	41	iii viii		01	02
Sub-		file		Sub-		file		Sub-		file	
I	3	00	54	I	3	00	34	I	3	00	14
2	2	02	14	2	2	01	53	2	2	01	30
3	I	03	35	3	I	03	12	3	I	02	47
v	vii	04	02	v	vii	04	33	v	vii	04	06
I	3	06	26	I	3	05	55	I	3	05	26
2	2	07	57	2	2	07	22	2	2	06	49
3	I	09	26	3	I	08	50	3	I	08	15
vi		11	05	vi		10	24	vi		09	44
I	3	12	51	I	3	12	09	I	3	11	22
2	2	14	38	2	2	13	50	2	2	13	08
3	I	16	38	3	I	15	45	3	I	14	57
vii	v	18	50	vii	v	17	52	iiiv	v	16	36
I	3	21	16	I	3	20	10	I	3	19	10
2	2	24	01	2	2	22	43	2	2	21	38
3	I	27	02	3	I	25	37	3	I	24	22
viii iii		30	30	viii iii		28	54	viii iii		27	30

South Declin- ing. 58 00			South Declin- ing. 59 00			South Declin- ing. 60 00		
Hours	D.	M.	Hours	D.	M.	Hours	D.	M.
2	2	122 10	3	I	114 02	3	I	119 20
3	I	113 18	x	ii	104 40	x	ii	108 40
x	ii	102 38	I	3	94 07	I	3	96 17
I	3	91 23	2	2	81 26	2	2	84 15
2	2	79 08	3	I	70 20	3	I	82 40
3	I	69 20	xi	i	60 28	xi	i	61 53
xi	i	60 10	I	3	51 57	I	3	52 10
I	3	51 10	2	2	44 56	2	2	45 35
2	2	44 20	3	I	38 58	3	I	39 27
3	I	38 39	xii		34 17	xii		34 33
xii		34 00	I	3	55 54	I	3	30 08
I	3	29 50	2	2	26 30	2	2	26 27
2	2	26 20	3	I	23 20	3	I	23 23
3	I	23 20	I	xi	20 38	I	xi	20 41
I	xi	20 39	I	3	18 17	I	3	18 20
I	3	18 23	2	2	16 10	2	2	16 11
2	2	16 13	3	I	14 13	3	I	14 16
3	I	14 18	ii	x	12 30	ii	x	12 31
ii	x	12 30	I	3	10 53	I	3	10 53
I	3	10 56	2	2	09 20	2	2	09 24
2	2	09 18	3	I	07 55	3	I	07 58
3	I	07 49	iii	ix	06 35	iii	ix	06 39
iii	ix	06 26	I	3	05 15	I	3	05 23
I	3	05 04	2	2	03 58	2	2	04 07
2	2	03 46	3	I	02 45	3	I	02 55
3	I	02 31	iiii	viii	01 31	iiii	viii	01 42
iiii	viii	01 16	I	3	00 19	I	3	00 33
I	3	00 02	Sub-	stile		Sub-	stile.	
Sub-	stile		2	2	00 52	2	2	00 34
2	2	01 10	3	I	02 05	3	I	01 25
3	I	02 25	v	vii	03 18	v	vii	02 56
v	vii	03 41	I	3	04 33	I	3	04 08
I	3	04 58	2	2	05 40	2	2	05 23
2	2	06 20	3	I	07 10	3	I	06 40
3	I	07 43	vi		08 35	vi		08 01

(58)				(59)				(60)			
vi	09	10		I	3	10	03	I	3	09	26
I	3	10	43	2	2	11	37	2	2	10	37
2	2	12	22	3	I	13	18	3	I	12	36
3	I	14	08	vii	v	15	09	vii	v	14	20
vii	v	16	03	I	3	17	10	I	3	16	15
I	3	18	08	2	2	19	23	2	2	18	22
2	2	20	30	3	I	21	56	3	I	20	45
3	I	23	10	viii	iiii	24	46	viii	iiii	23	28
viii	iiii	26	11								

CHAP.

CHAP X.

Of the Meridians of other Countries, and how to insert them into any Sun-Dial.

IT is easie to insert the *Meridian* of any other *Country* into any *Sun-Dial*, made for any other *Place*; if first you know the difference of *Longitude*, between the two *Countrys*, in *Time*; and also, whether the *Remote Country* lie *Eastward* or *Westward*, from the *Home Country*: For,

If the *Remote Country* lie *Eastward* of the *Home Country*, it is *Noon* sooner than it is at that *Place* the *Dial* doth stand in; if it lie *Westward* then it is *Noon* later.

As for Example,

Suppose that in a *Sun-Dial* here at *London*, you would insert the *Meridian* or *Noon-tide* of *Constantinople*, by the best *Geographers*, the *Meridian* of *Constantinople* lies *Eastward* of the *Meridian* of *London*, 30 deg: 45 min. which converted into *Time* by allowing 15 degrees to one hour, and 1 degree to 4 minutes of *Time*, it is 2 hours and 15 min. that is 2 hours and a quarter. Wherefore if you subtract 2 hours 15 min. from 12 hours, the *Remainder* will be 9 hours 45 min. or 3 quarters of an hour. Therefore if upon a *Dial* here at *London*, you write the word *Constantinople*, upon the *Hour-line* of 9 and 3 quarters, [or make this *,] the shadow of the *Stile* of the *Dial*, when it shall fall upon the *Word* or *Mark*, you may conclude it to be *Noon* at *Constantinople*; and knowing that, it is easily known what hour it is at any time of the *Day*.

You have several *Countries* inserted in the *Direct South-Dial*. Fig. 5. K A

A Table for Constantinople.

London.		Constantinople.	
For if it be	4	6	15
	5	7	15
	6	8	15
	7	9	15
	8	10	15
	10	11	15
	11	12	15
	12	*	15
	1	1	15
	2	2	15
	3	3	15
	4	4	15
Afternoon.	5	5	15
	6	6	15
	7	7	15
	8	8	15
		9	15
		10	15
			15
			15

Morning.

{ Of the Clock at London, }
it is at Constantinople.

Morning.

Afternoon.

A TABLE of Longitudes, or Difference of Meridians in Time, of several Eminent Places in the World from LONDON.

Places lying East of London.	Difference in Time. h. m.	Places lying West of London.	Difference in Time. h. m.
Amsterdam in Holland	0 21	Boston in New England	4 40
Agra	5 34	Barbadoes	3 53
Aleppo in Spain	2 40	Bermudus	4 14
Bantam	7 1	Cape Farewel	3 13
Bagdat	3 14	Cape Raze	3 16
Copenhagen	0 49	Carleton Inf.	5 18
Cape of Good Hope	1 9	Charles's Town	5 44
Cracovia	1 20	Dublin	0 26
Constantinople	2 15	Edenborough	0 2
Caro	2 16	James's Town	5 12
Dantzick	1 18	Lisbon in Portugal	0 36
Fort St. George	5 30	Madrid	0 16
Jerusalem	2 30	Madera	1 18
Jedo	9 16	Mexico	6 57
Isfahan	3 46	New York	4 58
Moscow	2 48	New Mexico	8 31
Nangefagne	8 32	Port Royal	5 4
Paris in France	0 10	P. Sir Francis Drake	9 40
Peking	7 51	S. Helena Inf.	0 20
Rome in Italy	1 6	Sevil in Spain	0 22
Stockholm	1 1	Surinam	3 42
Surrat	5 6	Tanger	0 29
Venice	1 1	Tenerif	1 22

Spot Dialling.

CHAP. XI.

Fig. 12 & 13.

Directions for making Two sorts of SPOT-DIALS, very useful to shew the Hour within the House.

A DESCRIPTION OF THE SPOT-DIAL

THE *Spot-Dial*, is of two sorts; in the one a bright Spot goes to the Lines, in the other the Lines go to a black Spot; the former being explained, the latter cannot be unknown. The manner of drawing the Hour-lines, is the same as was shewed on any other Dials, in the foregoing Chapters; but consider, if there was an Axis or Stile on this Dial, it would pass through the Back-board (which all such Dials must have) and the very Point where the Axis doth go through, is the Place where a hole in the one, and a spot in the other

other is to be made, that at any time [the Sun shining] will shew you the Hour of the Day.

S E C T. I.

For the making of these Dials.

1. Get the Joyner to make you a moulded Wooden Frame, with miter-joynts, like the frame of a Looking-Glass, or such a Gilt Frame, as are made for Pictures; about 8 Inches long, 5 Inches broad, and an Inch and half thick, and nail upon one of the longest edges of the Frame a piece of thin Board a little longer then the Frame, and but half as broad: This piece of board is for the bottom, and be sure that your Frame stands exactly perpendicular upon the bottom piece: Then for the back of your Frame, get a thin Plate of Wood, exactly fit for it, and at the Top of this Plate of Wood make a hole about 3 Inches long, and two Inches broad, and upon that nail a piece of Tin, or rather Copper-Plate.

2. You must get a piece of Crown Glass fit for your Frame, and grinde one side of it till it is as lucid as Paper, thus: Lay your Glass upon a Linnen, or Woollen Cloth to keep it from breaking; then with a small piece of Glass, and *Calice-Sand* grinde your Glass; but you must have a great care not to grind the other side; for in little time you may so smutch the Glass by heedless mistake of the side, as to make it useless.

3. Having found the Declination of your *Glass-Window*, against which it is to stand, make a Dial exactly the bigness of your Glass upon Paper, to that Declination, with *Stile* and *Substile* drawn upon the Paper, as if you were to make it for the

the Wall without Doors, or outside of the *Window*: But the Figures of this *Paper-Dial* must be inverted, or made backward as in Figure 13; and if you Write in *Roman Letters*, for Nine you must Write Eleven; and therefore your best way is to have a Copy before you, of Figures so drawn.

4. Now to find where the Spot will be; remember that it will be always in the *Substile*, and as far distant from the *Stile*, as is the distance between your Glass and the Tin: Put therefore your Glass already ground, into the Frame, and take the nearest distance between your Glass and Tin; for this end make a square of Paper; and applying one side to the Glass as it lies in the Frame, make a point at the nearest distance, and clip off the rest of the Paper at that point; with that distance come to your Dial on the Paper, and lay the longest edge of this square to the *Substile*, and carry it backward or forward upon the *Substile*, till the marked point just toucheth the *Stile*; then holding it, draw a line from the *Substile* to the *Stile*, and mark that point upon the *Paper-Dial*, where this Line cutteth the *Substile*, viz. at the corner of the square, (which I call the *Substile-point*) and draw a round $\odot$ about it, that you may know it again.

5. Having drawn your *Paper-Dial* the Exact bigness of your Glass, and found your *Substile-point*, you must draw the *Hour-lines* upon the rough side of the Glass, thus: Wet the Figured side of your *Paper-Dial* with Gum-water, and lay it on the smooth side of your Glass; and when it is dry, set one Foot of your Compasses upon the Center of the *Dial*, and open the other to the *Substile-point*; with that distance describe a *Small circle*

micircle, and from that *Semicircle* draw all your *Hour-lines* with a Pen and Ink, by the side of a Ruler upon the rough side of the Glass; your Figures must be drawn wrong as they appear through the Glass, which you will find to be right when your *Dial* is in the Frame, and finished.

6. Mark your *Substile-point* upon your Glass, and take off your *Paper-Dial*.

7. Make fast your Glass in the Frame with small Tacks, the rough side next the *Back-board*.

8. Make a little hole in the Tin, perpendicular over against the *Substile-point*, which you will find by the *Paper-square*; by which you may draw a perpendicular Line from the *Substile-point*, and Ink it upon the Top of the Frame, and so draw it down your *Back-board*; then take the Distance from the *Substile-point* to the outermost Edge, or Top of the Frame, and set it upon your line drawn on your *Back-board*, from the Top downwards, which distance will be perpendicular over your *Substile-point*.

9 And Lastly, with *White-Lead* and *Linseed-Oyl* ground together, Paint the rough side of the Glass; then glue on your *Back-board*, and your *Dial* is finished.

Now your *Dial* being made, set it close to your *Glass-Window*, and the *Sun* entring thro' the little hole, will cast its Ray upon the opposite *Hour-lines*, and so give the time of the Day.

I need not say much of that Form, wherein the Lines go to the *Spot*, for it is but the same inverted, as if you should turn this upside down, and draw the Lines towards the *Window* or *Street*, upon a clear *Transparent Glass*, and on the inside toward the *House*, instead of the Plate of *Wood*,
and

and the *Tin*, you must have a *Glass* ground, with one black *Spot* at the bottom, where the hole is in the *Tin*, unto which *Spot* every Line will come successively, according to the time of the day ; and the Figures must be made upon the clear *Glass* at Top ; and there must be a great square Quarry of *Glass* in the *Window* behind it, for the *Leads* will make a very unhandsome Confusion.

S E C T II.

How to draw Hour-Lines upon the Window-board, Walls, and Floor of a Room, the Sun shining through a small Hole made in any Pane or Quarry of Glass in the Window.

First, if in the *Glass-Window* of any Room, one *Pane* or *Quarry* of *Glass* be darkned, and a *Hole* made about half a quarter of an Inch Diameter in the middle thereof, the *Sun* shining upon the *Window*, will through that hole cast a bright *Spot* of *Light* into the Room, which as the *Sun* in his motion passeth by the *Window*, the *Spot* of *Light* will be also removed from place to place, sometimes upon the *Window-board*, sometimes upon the *Jambs*, sometimes upon the *Sides*, and sometimes upon the *Floor* of the Room. If such a *Hole* should be supposed to be the *Nodus* or *Point* of the Top of the perpendicular *Stile* of any *Dial*, I say from it the *Hour-lines* of a *Sun-Dial*, or of several *Dials* [for every side or part of the Room is a different *Plane*] may be made about the Room. If,

1. *Horizontally*

1. *Horizontally* you apply an *Horizontal-Dial* to the *Hole* in the *Glass-Window*, and extend a thread *Horizontally* also from that *Hole*, over every *Hour-line* [or half and quarter *Hour-line*] till it touch the *Sides*, *Doors*, *Windows*, *Jambs*, or other *Objects* or *Impediments* [standing in the way] about the *Room*: Then,

2. The Twelve a Clock *Hour-line*, being both an *Hour-line*, and an *Azimuth* also; you may [by a perpendicular Thread, or Threads, transfer the same to the *Cieling* or *Floor* of your *Room*, or to which of them will best serve your Turn. and sometimes there may be occasion for both: Then,

3. In this *Meridian Line* find any *Point*, from which a Line or Thread extended to the *Hole* in the *Window*, may represent either the *Direct* [or *Reverted*] *Axis* of the *World*, and unto that *Point* or *Points*; all the *Hour-lines* which you draw in that *Room* will have respect unto, [or be in the same *Plane* with] this *Axis*: And therefore,

4. If you fix a Thread in one or both of these *Points*, [or *Poles* rather] and extend that *String* by the side of another *String*, extended from the *Hole* over any *Hour-line* or *Point*, found on the side of the *Room* [as before] that moveable *String* being gently moved by the side of the *Horizontal String*, shall trace out [upon all *Objects* that it meets withal] the *Hour-lines*, which the extended *Horizontal String* doth represent.

Concave Dialling

CHAP. XII.

How to draw Hour-Lines in the Inside of Regular Concave Hemispheres.

THESE *Regular Concave Hemispheres* are the most natural *Planes*, upon which *Hour-lines* may be described, for they do naturally represent the *Sphere*; and the manner how the *Hour-lines* and *Furniture* may be described, into such *Dials*, shall be the Work of this and the next Chapter.

SECT. I.

Fig. 14.

To make a Horizontal Concave Dial:

HAVING a *Concave Hemisphere* prepared: as, S. N. E. W. divide the Limb into 4 Quadrants, noted as the former Letters; one of the Quadrants divided into 90 deg. open your Compasses to the Quadrant, and setting one foot upon E. or W. with the other, draw the *Meridian* or 12 a Clock *Hour-line* S Z N take out of the Quadrant, the *Latitude* 51 deg. 30 min. and set those degrees upon the *Meridian* from S, towards Z to P, which P shall be the *Pole of the World*; then placing your Compasses upon P, [they being opened

opened to a Quadrant] draw the *Equinoctial Circle* EÆW, which divide into 12 equal parts; your Compasses being opened as before to a Quadrant, and one foot being placed in those marks, made in the *Equinoctial*, with the other foot describe Circles, which shall be the Hour-lines required; the *Stile* must be erected in P, with an Angle of 51 deg. 30 min. the *Latitude* of the place; and equal to the length of 60 deg. of the Quadrant, the Top must hang over the Center of the *Hemisphere* Z, and be parallel with the Limb, or erect a *Stile* in the Point Z, of the same length with the former, which shall show the hour with the Top only.

SECT. II.

How to make a Direct, South or North Concave Dial.

THIS Dial is made altogether like the former, only instead of setting off the *Latitude* from S to P, you must only set off the Complement of the *Latitude* 38 deg. 30 min. and the *Hour-lines* only from 6 to 6, are described thereon; the rest of the *Hour-lines*, are reserved for a *Direct-Dial* beholding the *North*.

SECT. III.

Fig. 15.

How to make a Direct East or West Concave Dial.

LET the *Hemisphere* be Z S N G, the Limb being divided into four Quadrants, and one of

(70)

of them into 90 deg. from N, upwards, and from S, downwards, set the *Latitude* to P, then open your Compasses to a Quadrant, one foot being set in P, with the other draw the Circle Q E A, which Circle divide into 12 equal parts, your Compasses being opened to a Quadrant, one foot placed in each of these marks, with the other draw Circles, which shall be the *Hour-lines* required, as in Figure 15, The *Stile* may be a *Wire* laid from P to P, or a *Wire* erected in the Center E, equal to the Semidiameter of the Quadrant; for better Instruction see the Figure, which is an *East Dial*.

In the same manner is an *Equinoctial Dial* made, only all the hours from 6 in the *Morning* till 6 at *Night*, must be drawn, as the rest above those proper for the *East* or *West Dials* are, and as the pricked hours 9 8 7 and 6, in the Figure.

Also the *Hour-line* of 6, viz. the Line P 6 P, must be P 12 P, and the rest number'd as in the Figure is expressed, and number'd with *Arithmetical Figures*.

S E C T. IV.

Fig. 16.

How to make a South or North Declining Concave Dial.

YOUR *Concave* being prepared, quartered and marked with the Letters Z N E W, your Compasses being opened to a Quadrant, and one foot in Z or N, draw the *Horizontal Circle* E S W, take the *Declination*, and prick it down in the *Horizontal Circle* from W to H, one foot of your Compasses remaining in H, and being opened to a Quadrant, describe the *Meridian*,

or

or hour of 12, in which from Z, set off the Complement of the *Latitude*, or from it's intersection with the *Horizontal Circle*, set off the *Latitude* to P, one foot of your Compasses being in P, and opened to a Quadrant, draw the *Equinoctial* QÆA, and where it is intersected by the hour of 12, begin to divide it into 12 equal parts, one foot of your Compasses being placed in each of these *Points*, and being opened to a Quadrant, draw *Lines* which shall be the *Hour-Lines* required. For the *Stile*, that must be erected in P, and the top of it must pass through the *Center* of the *Limb* of the *Concave*, and be equal to the length of 60 deg. of the Quadrant, or you may erect the *Stile*, in the point S, the length equal to the former; which will shew the hour of the day with the very top of it.

Note, This Figure Declines *West*; which if it had Declined *East*, the Declination must have been set from E.

SECT. V.

How to make a Polar Concave-Dial.

A *Polar Concave-Dial*, is nothing but an *Horizontal-Dial*, in the *Latitude* of 90 deg. and of all others is most easie to be made, for if you divide the *Limb*, of the *Concave Hemispheres* into 24 equal Parts, and from the *Center* of the *Concave*, (by help of a thin Ruler that will bend) draw streight *Lines* to each of them, those shall be the *Hour-Lines* required.

For the *Stile*, it must be a streight Wire erected Perpendicular in the *Center* of the *Concave*, whose shadow will at all times (the *Sun* shining) give the hour of the Day, and the hours of these *Dials*, must be numbred from 12 to 12.

Of the Furniture in Concave-Dials.

CHAP. XIII.

SECT I. *How to draw the Parallels of the Sun's Declination, in the foregoing Concave Dials.*

THE *Equator* being drawn, set off the degrees of *Declination* from the *Equator* in the *Meridian* of the *Concave* or *Substilar*, both upwards and downwards; then place one foot of your *Compasses* in the *Pole*, and extend the other to those you marked, from the *Equator* draw *Circles*, which shall be the *Parallels* of the *Sun's Declination* required; As for *Example*, the drawing of the two *Tropicks*, which declines 23 deg. 30 min. from the *Equator*; take 23 deg. 30 min. and prick it down in the *Meridian* both ways, then place one foot of your *Compasses* in the *Pole*, and with the other extended to 23 deg. 30 min. describe the two *Tropicks*; as in *Figure 1.* appears.

SECT. II.

How to draw the Azimuths or Vertical Circles.

DIVIDE the *Horizon* into 180 deg. beginning where it's intersected by the *Meridian*; if you

you would draw every 10th *Azimuth*, then you may only divide it into 18 equal parts, beginning at the same place; but if you would only draw every 15 *Azimuth*, then divide the *Horizon* into 12 equal parts, beginning as before at the *Meridian*, if you would draw the Points of the *Compass*, divide the *Horizon* into 16 parts, then open your *Compasses* to a Quadrant, place one foot in any of those *Divisions*, and where the other foot intersects the *Horizontal Line*, shall be the Center for drawing that *Azimuth*.

S E C T II.

How to draw Planetary or Unequal Hours.

FOR the drawing of the *Planetary Hours*, having first described the *Horizon*, *Equator*, and the two *Tropicks*, divide that part of the *Tropick* which is intercepted betwixt its intersection with the *Horizontal-Circle*, into 12 equal parts beginning at 12; the *Equator* being before divided into 12 equal parts by the *Hour-lines*; open your *Compasses* to a Quadrant, one foot being placed in one of those *Divisions*, move the other foot until you find the Center, which will draw both those Points into one Circle; and draw Circles which shall be the *unequal Hours* required.

S E C T. IV.

How to draw Hours from Sun Rise, to Sun Set, called the Italian and Babylonish Hours.

PLace one foot of your *Compasses* in the *Pole*, and extend the other to the intersection of the

the

the *Horizon* and *Meridian*, and describe the *Parallel* of the *Latitude*, which shall be divided into 24 equal parts by the *Hour-circles*, place one foot of your *Compasses* in each of those *Divisions* (the *Compasses* being opened to a *Quadrant*) the other foot, being placed within the *Circle* of *Latitude*, and in the *Hour Circle*, which passeth through the *Points* where the *Compasses* is set in the *Circle*; making that the *Center*, describe *Circles* from one *Tropick* to another, which shall be the *Hour-lines* from *Sun Rise* to *Sun Set*; and shall pass by the intersection of the *Hour-lines* and the *Equator*.

SECT. V.

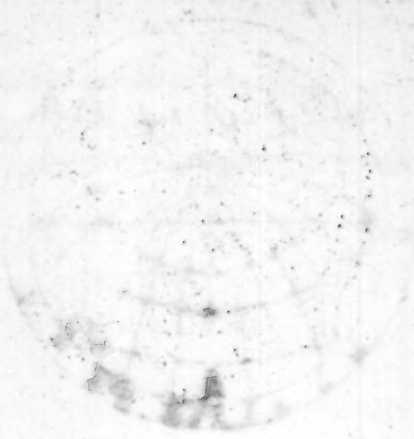
How to draw the Almicanter.

Having found the *Points* of *Zenith* and *Nadir*, the distance of these *Points* to the *Horizontal-Line* into 90 deg. one foot being placed on one of those *Points*, the other extend to those degrees, *Circles* drawn from one *Tropick* to another, shall give *Almicanter*s or *Circles* of *Altitude*.

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of the Clock *Hour-points* behold one the *East* and the other the *West* part of the *Horizon*; and then the *Sun*, at all times shining upon the *Globe*, will Enlighten one *Hemisphere*, and the other will be Shadowed, and where the Line of Shadow falleth amongst the *Hour-points* upon the *Equinoctial*, it will shew the *Hour* of the *Day*, in two places, *viz.* one on the *East*, and another on the *West* side of the *Globe*.

Note, If you open your *Compasses* to a Quarter of the distance, round the *Equinoctial Circle* of your *Globe*, and place one foot in the marks made in the *Equinoctial*, with the other you may describe the *Hour-lines*, from one *Tropick* to the other, or if you will from one *Pole* to the other.

A T A B L E containing the Latitude, of most of
the Eminent Cities and Towns in England, Scot-
land and Ireland.

Places in England and Wales	D.	M.	Places in England and Wales.	D.	M.
L O N D O N	51	30	Rochester	51	29
York	54	00	Peterborough	52	33
Oxford	51	54	Chichester	53	50
Cambridg	52	17	Hertford	51	51
Norwich	52	44	Newark	53	2
Canterbury	51	27	Stafford	52	55
Bristol	51	30	Shrewsbury	52	48
Colchester	52	4	Lancaster	54	8
Glocester	52	0	Winchester	51	10
Hereford	52	14	Leicester	52	40
Monmouth	51	51	Pembroke	51	46
Yarmouth	52	45	Worcester	52	20
Warwick	52	25	In Scotland		
Flint	53	17	E D E N B U R G	55	56
Salisbury	57	0	Glasgow	55	52
Northampton	52	18	St. John's	57	44
Newcastle	54	58	St. Andrew's	57	45
Lincoln	53	15	Sterling	57	18
Nottingham	53	3	Berwick	55	49
Boston	53	2	Aberdene	58	40
Chester	53	20	In Ireland		
Wakefield	53	54	D U B L I N	53	11
Coventry	52	30	Kingsale	51	40
Darby	53	6	Cork	51	47
Bedford	52	18	Wexford	52	18
Huntingdon	52	99	Waterford	52	22
Carmarthen	52	2	Limerick	52	30
Hull	53	50	Tredagh	53	38
Ipswich	52	08	King's Town	53	08
St. David's	52	00	Queen's Town	52	52

Instrumental Dialling.

By a Ruler, *accommodated with Scales, and Lines necessary for that purpose.*

CHAP XV.

A Description of the Scales, and Lines on the Ruler.

THE first Scale is a Scale of six Hours, each hour divided into halves and quarters of hours, being proper for *Dials* that have no *Declination*, as the *Horizontal*, the direct *South* or *North*, whether upright or Reclining.

Moreover, each hour is subdivided into as many unequal parts, as the length of the Scale will permit: This Scale is of special use in describing all other *Dials* that have *Centers*; where the height of the *Stile* above the *Plain*, is not less then 10 degrees: When that happens, there are other Scales to perform it with speed and exactness.

This Scale hath the letters (*Hour*) at the beginning.

The second Scale is a Scale of 90 degrees, answerable to the Scale of *Hours*, every deg. being
sub

sub-divided into as many parts, as the length will give leave. *Note*, that the first and second *Scale* together, will shew how many deg. and min. of time, are contained in any number of deg. and min. of the *Equinoctial* under 90, &c.

Example.

Against 20 deg. on the second *Scale*, you shall find on the first *Scale* 1 hour 20 min. and against 50 deg. on the second *Scale*, you shall find 3 hours 20 min. and so of any other Number whatever, if carefully computed.

The Third *Scale*, is a *Scale* of *Latitudes*, known by the letters (Lat.) at the beginning.

The fourth and fifth *Scales*, are two *Scales* of *Hours* of different length, either of them will serve to make all Direct *East* or *West*, and *Equinoctial Dials*, also all *Equinoctial Declining Dials*.

Both these *Scales* together, serves for the speedy drawing the *Hour-Lines* on all sorts of *Planes* or *Dials*, where the height of the *Stile* is but small, and the *Center* (of the *Dial*) left out. These *Scales* are known by the Letters (G Pol.) and (L Pol.) at the beginning.

Lastly, you must have two or three *Lines* of *Chords* (upon your *Ruler*) of several *Radius's* serving to protract and measure *Angles*.

CHAP. XVI

Fig. 17.

How to draw an Horizontal Dial, for the Latitude of 51 deg. 30 min.

1. **D**raw the line A B, for 6 a Clock Morning and Evening.
2. Draw N S, *Perpendicular* to A B; this line shall be the *Meridian* or 12 a Clock *Hour-line*.

3. Let

3. Let C, the intersection of the foresaid *Lines* be the *Center* of the *Dial*; then repair to your *Scale* of *Latitudes*, fixing one foot of your *Compasses* at the beginning, extend the other to 51 deg. 30 min. and set off that extent from C to A, and from C to B, then open your *Compasses* to the length of the whole *Scale* of *Hours*, and with that extent, one foot fixt in A, move the other till it meet with the *Meridian-line* N S, as at O, and draw the lines A O, and B O.

4. This done, extend your *Compasses* from the beginning of your hour *Scale* to the hour 1, and set off that extent from O to 1, and from O to 11, also the same extent must be set from A to 5, and from B to 7. Then extend your *Compasses* from the beginning of the said *Scale* to 2, and set it off from O to 2, and from O to 10, also from A to 4, and from B to 8; Lastly, extend your *Compasses* from the beginning of the said *Scale* to 3, and set that off from O to 3, and from O to 9: So you have Points for 12 hours. Now lines drawn from the *Center* C to each of those Points, shall be the hours required.

Note. That the hours of 4 and 5 in the Morning, and 7 and, 8 in the Evening, must be drawn through the *Center* C; and if you desire the halves and quarters, they are to be drawn in all respects as the *Hours*.

2. With a *Line* of *Chords*, make an Angle of 51 deg. 30 min. for the *Stile* of your *Dial*, and set it over the *Substile* or *Meridian-line* C O, at Right Angles, and your *Dial* is finished.

CHAP. XVII.

How to draw the Hour-lines upon a Direct South Dial in the Latitude of 51 deg. 30 min.

IT is almost needless to say any thing concerning the marking of a *Direct South Dial*, for there is but little difference between it and the *Horizontal*, only you must take Notice that this *Plane* respecteth the *South Pole*, which *Pole* is elevated thereon 38 deg. 30 min. (always) the Complement of the *Latitude*, therefore take 38 deg. 30 min. out of your *Scale* of Latitudes, and finish your *Dial* in all respects as you did the *Horizontal*: but observe, that whereas in that *Dial*, the Hours of 1, 2, 3, &c. were set off on your *Left-hand* of the *Meridian*, so the same *Hours* must in this *Dial* be set off on your *Right-Hand* of the *Meridian*; if you well observe what was said in the IXth. Chapter, Page 27.

Note, 1. That the *Angle* which the *Stile* makes with the *Meridian*, must (as I have said before) be 38 deg. 30 min.

2. And Lastly, that the *Stile* must stand at Right *Angles* with the *Plane*.

CHAP. XVIII.

Concerning a Direct North Dial.

A *Direct North Dial*, is the same with the *South*, only the *Stile* must point upwards toward the *North-Pole*, and the hours about Mid-

(88)
Mid-night, as 9, 10, 11, 12: 1, 2, and 3 must be left out, and 4 and 5 in the Morning, and 7 and 8 at Night must be drawn through the Center, as in the *Horizontal Dial*: So is your *North Dial* finished.

C H A P. XIX.

How to find the Reclination of any Plane.

TAKE a *Quadrant* and joyn it to the *Side* of a *Square*, and place the other *Side* of your *Square* to the *Plane*; if the *Plummet* fall *Parallel* to the *Side* of the *Square*, then the *Lower-side* of the *Square* stands *Level*, by which draw an *Horizontal-Line*, on which erect a *Perpendicular*, and apply your *Square* to that *Perpendicular*, and if the *Plummet* falls *Parallel* to the *Side* of the *Square*, then that is also a *Levil Line*, and your *Plane* stands *Horizontally*: If the *Plummet* falls not *Parallel* to the *Side* of the *Square*, then turn your *Square* until it does, then draw an *Horizontal-Line*, on which erect a *Perpendicular* to which apply your *Square*, and observe what *Angle* your *Plummet* makes on the *Quadrant*, with the *Side* of the *Square*, that is the *Angle* of the *Reclination* of the *Plane*.

C H A P. XX.

How to draw the Hour-Lines, upon Direct South or North Reclining Dials.

SUCH *Planes* as do directly behold the
{ *North* }
{ *South* } Point of the *Horizon*, but do
Re.

Reclining (or fall backward) from the *Zenith* towards the { *South* } are called { *North* } *Direct* *Planes Reclining*: So many Degrees as the *Reclination* is: And of such *Planes* there are Six *Varieties*; Three of *South*, and Three of *North Recliners*: All which may be *Reduced* to *New Latitudes*, wherein they will become *Horizontal Planes*: And consequently *Dials* (or *Hour-lines*) may be described upon them by the *Precepts* delivered in the *XVIth* Chapter.

1. Of South Recliners.

Examples of all these *Varieties* of *Reclining Planes*, in the *Latitude* of *London* 51 deg. 30 min. To find the *New Latitude*.

1. Variety. Let there be a *Direct South Plane* in the *Latitude* of *London*, which *Reclines* from the *Zenith* thereof 20 deg. In what *Latitude* will that be an *Horizontal Plane*? The *Planes Reclinations* 20 deg. being less than 38 deg. 30 min. the *Complement* of the *Latitude* of *London*; Subtract 20 deg. from 38 deg. 30 min. the *Remainder* (or difference) 18 deg. 30 min. is the *New Latitude*. So that an *Horizontal Dial* made for that *Latitude* shall be a *South Reclining* 20 deg. in the *Latitude* of *London*.

2. Variety. If a *South Plain* in the *Latitude* of 51 deg. 30 min. should *Recline* 60 deg. from the *Zenith* thereof: In what *Latitude* will that be an *Horizontal Plane*?

The *Reclination* of the *Plane* 60 deg. being greater than 38 deg. 30 min. the *Complement* of the *Latitude* of *London*, Subtract 38 deg. 30 min. from 60 deg. and the *Remainder* 21 deg. 30 min.

is the *New-Latitude*: And a *Horizontal Dial* made for that *Latitude* of 21 deg. 30 min. shall serve for a *South Dial Reclining* 60 deg. in the *Latitude* of *London*.

3. Variety. If a *South Plane* in the *Latitude* of *London* should *Recline* from the *Zenith* thereof 38 deg. 30 min. Equal to the *Complement* of the *Latitude* of *London*. Then,

The difference between the *Complement* of the *Latitude* of *London* and the *Reclination* being nothing; it shews the *New-Latitude* to be no *Latitude*, that is neither *Pole* hath any *Elevation* over such a *Plane*, but is an *Equinoctial Plane*, and must be made by the Rules delivered in the 24th Chapter of this Book.

2. Of North Recliners.

1. Variety. If a *North Plane* in the *Latitude* of 51 deg. 30 min. should *Recline* from the *Zenith* 20 deg. In what *Latitude* will that be an *Horizontal Plane*?

The *Reclination* 20 deg. being less then the *Complement* of the *Latitude* of *London*, 38 deg. 30 min. add the *Reclination* 20 deg. and the *Co-Latitude* 38 deg. 30 min together; their sum 58 deg. 30 min. is the *New Latitude*: And an *Horizontal Dial* for that shall be a *North Plane Reclining* 20 deg. in the *Latitude* of 51 deg. 30 min.

2. Variety. If a *North-Plane* in the *Latitude* of *London*, 51 deg. 30 min. should *Recline* from the *Zenith* 75 deg. In what *Latitude* will such a *Plane* be *Horizontal*?

The *Reclination* 75 deg. being Greater than 38 deg. 30 min. Add them together and they make

make 113 deg. 30 min. which being above 90 deg. take the *Complement* thereof to 180 deg. which is 66 deg. 30 min. And that is the *New-Latitude*: So that an *Horizontal Dial* made for the *Latitude* of 66 deg. 30 min. will be a *North Plane Reclining* 75 deg. in the *Latitude* of *London* 51 deg. 30 min.

3. Variety. If a *North Plain* in the *Latitude* of *London* 51 deg. 30 min. should *Recline* from the *Zenith* thereof 51 deg. 30 min. In what *Latitude* will such a *Plain* be *Horizontal*?

Here the *Reclination* 51 deg. 30 min. is Equal to the *Latitude* of *London*; and the Sum of the *Reclination* 51 deg. 30 min. and the *Complement* of the *Latitude* 38 deg. 30 min. Added together, their Sum is 90 deg. for the *New-Latitude*: And an *Horizontal Dial* made for that *Latitude* of 90 deg. will be a *North Plane Reclining* 51 deg. 30 min. in the *Latitude* of *London*, and must be made by the Rules delivered in the 30th Chapter of this Book.

Note also: That in making of any of these *North* or *South Reclining Dials*, you have made also a *Direct North* or *South Dial* inclining from the *Zenith* towards the *Horizon*, so many Degrees

as the { *Recli-*
 Incli- } nation.

So that when you have made a *South-Dial* *Reclining* from the *Zenith* 60 deg. (as is the *Second Variety* of *South Recliners* in this Chapter) you have also a *North Dial* *Inclining* to the *Horizon* 60 deg. either by drawing the *Hour-lines* and *Stile* through the *Center*, or by turning the *Reclining Dial* about upon the *Hour-line* of VI. And then, as the *North Pole* is *Elevated* upon the *South Recliner*; so much will the *South Pole* be *Elevated* above the *North Incliner*, &c.

CHAP. XXI.

A general Rule to know which Pole, whither the North or the South, is to be elevated over any Plane.

THE Stile of every *Dial*, respecteth (or rather lieth parallel with) the *Axis* of the World, and always pointeth upwards or downwards, to one of the *Poles*. Now when you have drawn your *Dial* (though truly) you may be to seek, whether it be the *North* or the *South Pole* that you must elevate; wherefore to avoid any mistake, and to inform you which *Pole* is to be elevated, Observe this general Rule,

Upon all *Upright Planes*, whether *Direct* or *Declining*, upon the *South-side* the *South Pole*.

Upon all *Upright Planes*, whether *Direct* or *Declining*, upon the *North-side* the *North Pole*.

Upon all *East* and *West Recliners*, the *North Pole*.

Upon all *East* and *West Incliners*, the *South Pole*.

Upon all *North Recliners*, whether *Direct* or *Declining*, the *North Pole*.

Upon all *South Incliners*, whether *Direct* or *Declining*, the *South Pole*.

Upon all *South Recliners*, whether *Direct* or *Declining*, if the *Plane* pass between the *Zenith* and the *Pole*, the *South Pole*; But if it pass between the *Pole*, and the *Horizon*, the *North Pole*.

Upon all *North Incliners*, whether *Direct* or *Declining*, if the *Plane* pass between the *Zenith* and the *Pole*, the *North Pole*; But if it pass between the *Pole*, and the *Horizon*, the *South Pole*.

CHAP. XXII.

How to draw the Hour-Lines, upon a Direct East or West Dial.

1. **U**PON the Point C, if it be an *East Dial*, or upon the point D, if a *West*, with 60 deg. of your *Line of Chords*, draw an obscure part of a Circle as AB, and in that Arch from A to B, set off the *height* of the *Equinoctial*, 38 deg. 30 min. and draw the line CDE, then in some convenient place of the line CE, as at R, draw the line GRF, at right Angles to the line EDC, so shall GRF, be the *Substile* and *Hour-line* of 6.

2. Draw IH, parallel to the line EDC.

3. Repair to either of your *Scales* known by the letters [*Pol.*] and fix one Foot of your Compasses at the beginning of the said *Scale*, and extend the other Foot to the *Hour* of 1. Set off that extent from G to 5, and from G to 7, and on its parallel EC, from R both ways, and draw the hours of 5 and 7 parallel to the *Substile* and *Hour-line* of 6: Then take in your Compasses the distance from the beginning of the *Scale*, to 2 hours, and set it off from G to 4, and from G to 8, and also from R both ways, and draw the hour of 4 and 8. parallel to the other; so you have now more hours to set off towards I, being 4 is the hour of Sun Rising; but proceed to set off the rest of the hours towards H, as you did the other hours, taking in your Compasses the distances from the beginning of the *Scale* to 3, 4, and 5, and setting each distance off respectively

pectively from G towards H, at 9, 10 and 11, and also from R towards C, and draw the hours of 9, 10, and 11: and so you have all the hours proper for an *East Dial*.

4. And Lastly, The distance the beginning of the *Scale* to the hour of 3, gives the height of the *Stile*, which must stand directly over the *Hour-line* of 6, making Right-Angles therewith, and may be made of a thin plate of Iron or Brass, or a Pin tharpned, whose extremity must give the shadow to the *Hour-lines* on the *Dial*.

Note, That if you turn the *East Dial* drawn on Paper from you, and look on the back-side, you shall see the perfect form of a *West Dial*, only instead of the Hours 11, 10, 9, 8, 7, 6, 5, 4, you must write 1, 2, 3, 4, 5, 6, 7, and 8.

C H A P. XXIII.

Fig 19.

Of Direct East or West Reclining Dials, and how Hour-lines may be described on them.

AS all *Direct North* and *South Reclining Planes* were reduced, to *New-Latitudes*, wherein they would be *Horizontal Planes*; and therefore made by the *Directions* given in the 16th Chapter hereof: So all *Direct East* or *West Reclining Dial Planes*, in any one *Latitude*, may be reduced to *Erect*, or *Upright Declining Planes*, in another *Latitude*: and therefore may be made by the *Precepts* delivered in the 27th Chapter hereof: So the work of this Chapter shall be only to shew,

I. How

I. How to reduce any *Direſt Eaſt* or *Weſt Reclining Plane* in any *Latitude* (ſuppoſe *London* 51 deg. 30 min.) to be a *New-Latitude*, wherein the *Reclining Plane* ſhall become and *Ereſt* (or *Upright Plane*. And,

II. What *Declination*, that *Upright Plane* ſhall have in that *New-Latitude*.

Example.

Suppoſe then, that a *Direſt Eaſt* or *Weſt Plane* in the *Latitude* of 51 deg. 30 min. ſhould *Recline* from the *Zenith* 40 deg. In what *Latitude* will that be an *Upright Plane*? And what *Declination* ſhall it have in that *Latitude*?

R U L E.

The *Complement* of the known *Latitude*, is (always) The *New-Latitude*. And

The *Complement* of the *Reclination* is (always) the *Declination* in that *New-Latitude*.

So that if an *Eaſt* or *Weſt Dial*, ſhould *Recline* 40 deg. in the *Latitude* of 51 deg. 30 min. that will be an *Upright Plane*, *Declining* 50 deg. in the *Latitude* of 38 deg. 30 min.

For 38 deg. 30 min. being the *Complement* of the *Latitude* of 51 deg. 30 min. is the *New-Latitude*: And 50 deg. being the *Complement* of 40 deg. the *Planes Reclination*, is the *Declination* in that *New-Latitude*.

So that if (according to the *Precepts* delivered in the 27th Chapter hereof) you make an *Upright Dial* for the *Latitude* of 38 deg. 30 min. to *Decline* 50 deg. Such a *Dial* will ſerve for an *Eaſt* or *Weſt Dial Reclining* 40 deg. in the *Latitude* of (*London*) 51 deg. 30 min.

Thus

Thus for the making of the *Dial*.

But in the placing of this *Dial* (thus made) upon the *Reclining Plane*, this difference is to be observed: For, Whereas in all *Upright Declining Planes*, the *Meridian* or *Hour-line* of XII, is always perpendicular to the *Horizon* of the Place for which it is made.

But this *Declining Plane* when it is applied to the *Reclining Plane*, the *Hour-line* of XII must lie Parallel to the *Horizon* of the Place, as in Figure 19.

And here *Note*, that all *East Recliners* in the known *Latitude* (as here *London*) are *North-East Decliners* in the *New Latitude*: And all *West Recliners*, are *North-West Decliners*.

And *Note* farther; That upon all *East* and *West Recliners* in the *North Latitudes*, that the *North Pole* is (always) elevated: And upon the *East*, and *West Inclining Planes* opposite to them, the *South Pole* is Elevated.

Lastly, *Note* that when you have made an *East* or *West Reclining Dial*, you have made Four, viz. An *East* and *West Reclining*, and an *East* and *West Inclining*.

C H A P. XXIV.

Fig. 20.

How to draw the Hour-Lines upon an Equinoctial Dial.

1. **D**raw the *Horizontal Line*, A B, with its Parallel C D, then draw the Perpendicular E F, which shall be the *Hour-line* of 12.
2. Repair to either of the *Scales* known by the Letters (*Pol.*) and fixing one foot of your *Compasses*

passes at the beginning of the said *Scale*, and extend the other foot to the Hour of 1, set off that extent from E to a 11, and from E to 1, as also from F both ways on the line A B, and draw the *Hour-lines* of 1, and 11, Parallel to the *Hour-line* of 12: Then again extend your Compasses from the beginning of the *Scale* to 2 Hours, set off that extent from E to 10, and from E to 2, also from F both ways, and draw the *Hour-lines* of 10 and 2: Then extend your Compasses from the beginning of the *Scale* to 3 Hours, and set off that from E to 9, and from E to 3, also from F both ways, and draw the *Hour-lines* of 9 and 3 Parallel to the former. Then extend your Compasses from the beginning of the *Scale* to 4 Hours, and set off that extent from E to 8, and from E to 4, also from F both ways, and draw the *Hour-lines* of 8 and 4.

3. And Lastly, extend your Compasses from the beginning of the *Scale* to 5 Hours, and set off that extent from E to 7, and from E to 5, also from F both ways, and draw the *Hour-lines* of 7 and 5, and so you have all the *Hours* proper for this *Plane*.

The *Stile* may be a thin Plate of Brais or Iron, that must stand Perpendicular upon the *Hour-line* of 12: The length thereof must be the distance between the *Hours* of 12 and 3; and so is your *Dial* finished:

CHAP. XXV.

How to make a Polar Dial.

MAke C A, and C B, equal to the whole Line of Latitudes, and proceed as if you were

were to make an *Horizontal Dial* (for the *Latitude* of 90 deg.) and set up a *Pin* of *Brass* or *Iron* of any length, *Perpendicular* in the *Center* of the *Dial*.

C H A P. XXVI.

Fig. 21.

How to draw the Hour-lines upon a South or North Plane, Declining either East or West.

BEfore the *Hour-lines* can be drawn upon any of these *Planes*, two things must be given, and three other things must be found.

The Things given must be,

1. The *Latitude* of the *Place*.
2. The *Declination* of the *Plane*,

The Things that must be found are,

1. The distance of the *Substile* from the *Meridian*, or 12t a-Clock *Hour-line*.
2. The height of the *Stile* above the *Plane*.
3. The *Inclination* of *Meridians*.

How to Calculate the Three Requisites that must be found, for all Upright Declining Dials in any Latitude.

The *Latitude* of the *Place*, 51 deg. 30 min.

The *Plane's Declination*, 25 deg. 00 min. *Westward*.

The Canon for Calculation is,

As the *Radius*, ————— 10.000000
 Is to the *Sine* of the *Declination*, 25 deg — 9.625948
 So is the *Co-Tang.* of the *Lat.* 51° 30' — 9.900605
 To the *Ta.* of the *Substile's dist.* 18° 34' 29.526753
 As

As the Radius 90 ————— 10.000000
 Is to the Co-Sine of the Decl. 25° ——— 9.957276
 So is the Co-Sine of the Lat. $51^{\circ}30'$ ——— 9.794149
 To the Sine of the Stile's height $34^{\circ}21'$ 9.751425

As the Radius 90 ————— 10.000000
 Is to the Co-Tang. of the Decl. 25° d. ——— 10.331327
 So is the Sine of the Lat. 51° d. 30 m. ——— 9.893544
 To the Co-Ta. of Incl. of the Mer. $30^{\circ}47'$ 10.224865

Having found the *Requisites* belonging to this Dial Declining 25 degrees Westward, proceed to draw the *Hour* in this manner.

1. Draw an *Horizontal* line upon your *Plane*.
2. Draw C 12 the *Meridian*, or 12 a Clock *Hour*-line, perpendicular to the *Horizontal*-line of the *Plane*, and with a Line of Chords, make the Angle F C 12, equal to the *Substile's* distance from the *Meridian*, and draw the line C F for the *Substile*, on the Right-hand of the *Meridian*, because the *Plane* Declines *West*.

3. Draw the Line A B perpendicular to the *Substile*, and passing through the Center at C; then out of your *Scale* of *Latitudes* take $34^{\circ} 21$ min. (the height of your *Stile*) and set from C to A, and from C to B; then take in your *Compasses* the whole *Scale* of *Six Hours*, and one foot in *A*, turn the other about till it will touch the *Meridian*, as at F, and draw the line F A, and F B.

4. The *Inclination* of the *Meridians* in this *Example*, is found to be 30° deg, 47 min. seek that in the second *Scale* of 90° deg. and just against it

on the first *Scale* you shall find 2 *Hours* 3 min. take off 2 *Hours* 3 min. from your *Scale*, and set it from F to 12, and from B to 6; then extend your *Compasses* from the beginning of the said *Scale* to 00 *Hours* 3 min. and set that from F to 2, and from B to 8. Then open your *Compasses* to 1 *Hour* 3 min. of the same *Scale*, and set it from F to 1, and from B to 7. Then open your *Compasses* to 3 *Hours* 3 min. and set it from F to 11, and from B to 5. Then open your *Compasses* to 4 *Hours* 3 min. and set it from F to 10, and from B to 4. Then open your *Compasses* to 5 *Hours* 3 min. and set it from F to 9, and from B to 3. Now if you draw Lines from C to these points, they will be the *Hours* proper for this *Plane*: The *Hour* of 8 in the *Afternoon* being above the *Horizontal* line, if you draw it through the *Center*, it will be the *Hour-line* of 8 in the *Morning*.

H. M.		From F to A.		From B to F.	5. And Lastly, the <i>Stile</i> for this <i>Dial</i> , must be elevated 34 deg. 21 min. and set Perpendicular upon the <i>Substile</i> . Note 1. In the drawing of this <i>Dial</i> , you have made 3 o- ther <i>Dials</i> that have the same <i>Declination</i> .
0	3	F	2	B	
1	3	F	1	B	
2	3	F	12	B	
3	3	F	11	B	
4	3	F	10	B	
5	3	F	9	B	

2. A *Dial* for the *South-East* face of the *Plane*, if you change the side, and the numbers set to the *Hours* the *Complement* of 12, that they are in the other, as 8, 9, 10, 11, 12, 1, 2, (*Substile*) 3, 4, 5, 6, 7, and 8, in the former, must be 4, 5, 6, 7, 8, 9, (*Substile*) 10, 11, 12, 1, 2, 3, and 4 in this *East Dial*. 3. If

3. If the face of your *Dial* be toward the *North*, you must turn the *Dials* the bottoms upward and reckon the *Hours* the contrary way; So that a *South East* Decliner will be a *North East* Decliner, and a *South West* Decliner will be a *North West* Decliner, leaving out the *Hour-lines* (which will be needless) before the *Sun-setting*, and after the *Sun-rising*.

C H A P. XXVII.

Fig. 22.

How to draw Hour-lines upon a Far Declining Dial, by the two Polar Scales on the Ruler.

Example of a South Dial Declining East 80 deg. in the Latitude of 51 deg 30 min.

BY the directions of the last Chapter, (or by the Table page the 29th) you shall find the *Inclination* of the *Meridians* to be 82 deg. 9 min. and the height of the *Stile* above the *Plane* 6 deg. 12 min. and the *Substile's* distance from the *Meridian* 38 deg. 4 min.

Proceed thus, draw first, the Perpendicular *G H*, then with the *Radius* of your line of *Chords*, describe the Arch *L M*, and set off the *Substile* and *Stile* with the same line of *Chords*, according to their respective Angles, and draw the pricked line *G B A* for the *Substile*, and *G I K* for the *Stile*.

Then choose any point in the *Substile*, as *A*, through which point *A*, draw a line at length, Perpendicular to it, as the line *E A C*, that done, fix one foot of your *Compasses* at the beginning of

of your longest *Polar Scale*, and extend the other to the *Hour* of 3, set off this extent from A to C, and through the point C draw a line Parallel to the *Stile* G I K, as the line C D, so shall C D be the *Stile* increased. Then open your *Compasses* from the beginning of your second or lesser *Polar Scale*, to 3 *Hours*, and with that extent, place one foot of your *Compasses* in the *Substile* A B G, carrying it along the said line, until the other foot of the *Compasses* just touch the line C D, and there make a mark, as at B, through which mark B, draw a line at length, and Parallel to the line E A C, as the line D B F. Then considering the *Inclination* of the *Meridian* was found to be 82 deg. 9 min. find it on the second *Scale* or *Scale* of 90 deg. and against it on the first *Scale* you shall find 5 *Hours* 29 *Minutes*, by which it appears that the *Substile* falleth between the *Hours* of 6 and 7 in the *Morning*.

Now according to the *Inclination* of *Meridians* 5 *Hours* 29 *Minutes*, you may proceed to make a *Table*, and set off the *Hours* accordingly, as followeth.

Open your *Compasses* to 00 *Hours* 29 min. of the greater *Polar Scale*, and set it from the *Hour* of 7, in the line E A C. Then open the *Compasses* to 1 *Hour* 29 min. of the same *Scale*, and set it from A to 8. Then open your *Compasses* to 2 *Hours* 29 min. and set it from A to 9. Then open your *Compasses* to 3 *Hours* 29 min. and set it from A to 10. Lastly, open the *Compasses* to 4 *Hours* 29 min. and set it from A to 11.

Now having found the points for the *Hours* on one side of the *Substile* from A towards E, you must do the like for the other *Hours* on the other
side

side of the Substile: And considering that the first *Hour* from the *Substile* towards E, namely A 7, contains the distance of 00 *Hours* 29 min. as by the following *Table*; the *Complement* thereof to 60 min. or an *Hour*, is 00 *Hours* 31 min. as by the said *Table* appears.

From A towards E.			From A towards C.		
H. M.	h on the Plane		H. M.	h on the Plane	
0 29	A	7	0 31	A	6
1 29	A	8	1 31	A	5
2 29	A	9	2 31	A	4
3 29	A	10	3 31	A	3
4 29	A	11	4 31	A	2

Proceed to set off 00 *Hours* 31 min. taken from the same *Polar Scale* from A to the *Hour* of 6, and extend your *Compasses* from the beginning of the *Scale* to 1 *Hour* 31 min. and set it from A to 5, also to 2 *Hours* 31 min. and set from A to 4, also to 3 *Hours* 31 min. and set it from A to 3; and Lastly, the extent of the *Compasses* from the beginning of the *Scale* to 4 *Hours* 31 min. set off from A to 2, and so you have points for all the *Hours* on the *Plane* on the line C A H.

Now for the other line D B F, you must set off the *Hours* thereon (taken out of the *lesser Polar Scale*) from B both ways according to the *Table*, in all respects as you did set off the *Hours* from A. This being done, draw lines through the respective Points found in the lines C A H, and D B F, and those lines shall be the *Hour-lines* for this *Dial*.
The

The *Stile* must be a *thin Plate* of *Brass* or *Iron*, and stand directly over the *Substile*, as in the *Figure* is demonstrated, by *A B* and *C D*.

Thus have you finished your *Dial*, and in the making of this you have made a *South Declining West* 80 deg. Also; for if you turn the *Paper*, and look through it, it will on the back-side appear *Declining West* 80 deg. only the *Forenoon* in this, must be the *Afternoon hours* in that: Nay, in rigour, you have in this one *Dial* made four, viz. a *North Declining*, either *East* or *West*.

CHAP. XXVIII.

Fig. 23.

How to draw the Hour-lines upon any Declining Equinoctial Plane.

Let the Example be of a *South Plane*, *Declining East* 65 deg. 40 min. and *Reclining* 18 deg. 9 min. in the *Latitude* of *London* 51 deg. 30 min.

IN *Declining Reclining Equinoctial Dials*, before the *Hour-lines* can be drawn, three things must be given, and two things found; the things given are,

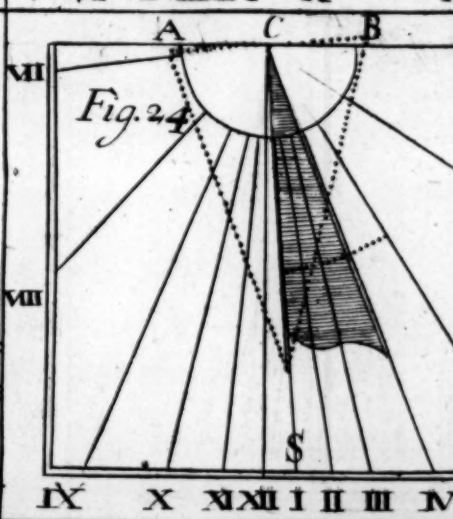
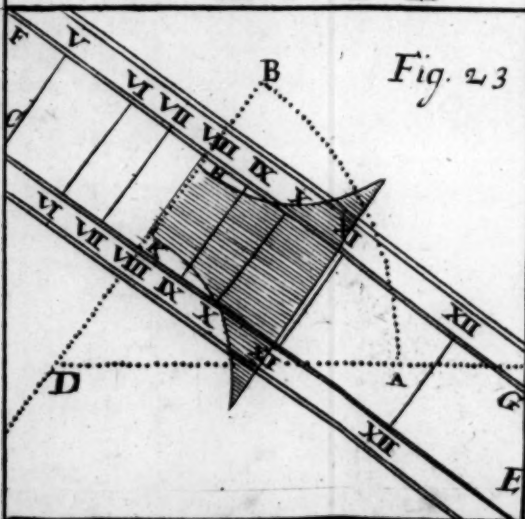
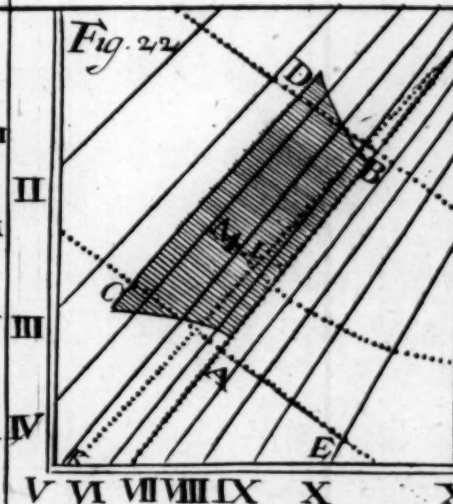
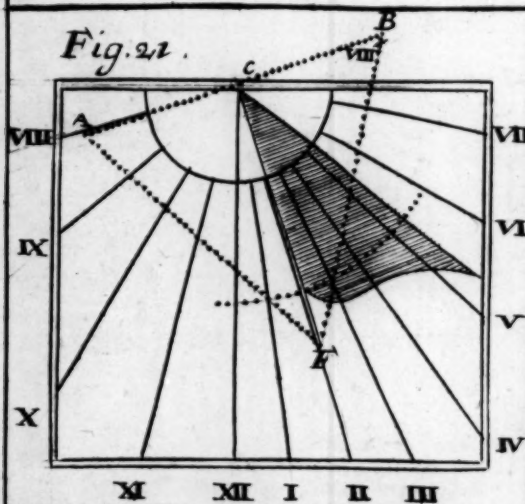
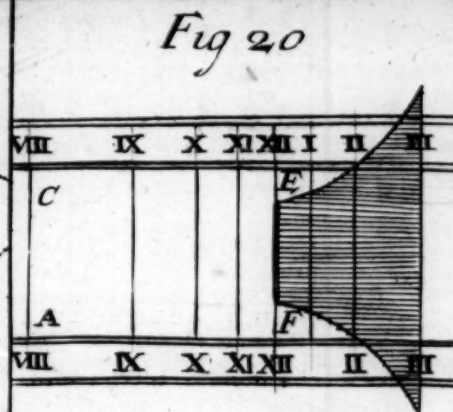
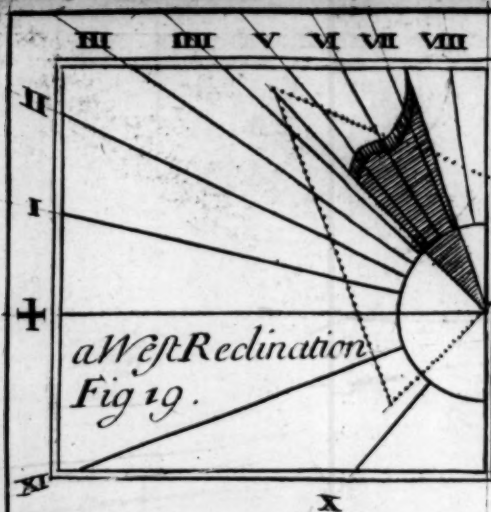
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|---|----------------------------------|----|----|
| { | 1. The Latitude of the Place, | 51 | 30 |
| | 2. The Declination of the Plane, | 65 | 40 |
| | 3. The Planes Reclination, | 18 | 9 |

The things found are,

- | | |
|---|---|
| { | 1. The distance of the <i>Meridian</i> and <i>Horizon</i> . |
| | 2. The Inclination of the <i>Meridians</i> . |

For the distance of the *Horizon* and the *Meridian*, Thus,

As



As the Radius, or Sine of 90 deg.—10.000000
 Is to the Sine of the Reclination, 18 9—9.493466
 So is the Tangent of the Declina. 65 40 10.344652
 To the Tangent of 34 deg. 34 min. —29.838118

Whose Complement 55 deg. 26 min. is the distance of the *Meridian* and *Substile* from the *Horizontal line*.

For the *Inclination* of the *Meridian* of the Place from the *Meridian* of the Plane, Thus,

As the Radius, or Sine of 90 deg — 10.000000
 Is to the Sine of the Latitude 51 30 — 9.893544
 So is the Tangent of the Decli. 65 40 — 10.344652
 To the Tangent of 59 deg. 55 min. —10.237196

Now because 59 deg. 55 min. is almost 4 hours distance from the *Meridian*, I conclude that the *Substile* shall fall near 8 of the Clock, on the *West* side of the *Meridian*: Because the *Plane* declineth *East*.

The Requisites being found, Draw the *Horizontal-line* D A, then with the *Radius* of your line of *Chords*, describe the Arch A B, and set thereon from A to B 55 deg. 26 min. the distance of the *Meridian* or *Substile* from the *Horizon*, and draw B D for the *Substile*. Then Perpendicular to the *Substile*, draw the lines F G and C E, having found the *Inclination* of *Meridians* to be 59 deg. 55 min. find it on the *second Scale*, and against it on the *first Scale* you shall find 3 hours 59 min.

Then having recourse to the Table following, set off the *Hours* from K and H, according to the directions of the 27th Chapter, for the *far decliner*, taking the several Distances with your

P

Com-

From K towards E.			From K towards C.		
H. M.	h. on the Plane		H. M.	h. on the Plane	
0	59	K	9	0	I
I	59	K	10	I	I
2	59	K	11	2	I
3	59	K	12	3	I
4	59	K	I	4	I

Compasses out of either of the *Polar Scales*, and setting them off from K towards C and E, as the *Table* plainly sheweth, drawing lines *parallel* to the *Substile* through those points, and those Lines shall be the *Hour-lines* required for that *Plane*.

The extent of the Compasses from the beginning of the same *Polar Scale* to the *Hour* of 3, gives the height of the *Stile* above the *Substile*, which may be a *Plate* of *Iron* or *Brass* set up just over the *Substile* H K; and so the *Dial* is finished.

CHAP XXIX.

Fig. 24.

Of Dial Planes that do both Decline and Recline: How Hour-lines, &c. are to be discribed upon them.

THESE *Planes* may also be *Reduced* to *New-Latitudes*, and *New-Declinations*, where they may stand as *Upright Decliners*: And so *Dials* may be discribed on them, by the *Directions* in the 26th Chapter hereof: And so to find the *New-Latitude*,

Latitude, and New-Declination of any such Plane, the Rules following will Direct.

Example.

Suppose that in the *Latitude of London* 51 deg. 30 min. a *South Plane* should *Decline* towards the *East* or *West* 24 deg. 20 min. and also *Recline* from the *Zenith* 54 deg.

1. *To find the New Latitude.*
The Canon for Calculation.

As the Radius, Sine 90 deg. ——— 10.000000
Is to the Co-sine of the *Old Decli.* 24°. 20' 9.959596
So is the Co-Tang. of the *Reclination* 54° 9.861261
To a Fourth Tangent, viz. 33° 30' — 9.820857

This *Fourth Tangent* being thus found, the Rules following are to be observed.

1. *In South Recliners.*

R U L E I. This *Fourth Tangent* must be compared with the *Old Latitude*, and the Complement of their *Difference* is the *New Latitude*.

So, in this *Example*, the *Fourth Arch* 33 deg. 30 min. being *Subtracted* from the *Old Latitude* 51 deg. 30 min. their difference is 18 deg. whose Complement 72 deg. is the *New Latitude*.

R U L E II. If the *Fourth Tangent* fall equal to the *Old Latitude*, then the *Difference* will be nothing; and so the *Plane* will be an *Equinoctial Declining Plane*, for the *Pole* will have no *Elevation* over it.

So, in the *Latitude* of 51 deg. 30 min. If a *South Plane* should *Decline* towards the *East* or *West*

West 65 deg. 40 min. And Recline 18 deg. 9 min. By the former Cannon, the Fourth Tangent will be found 51 deg. 30 min. equal to the Old-Latitude: So that the Difference is nothing. And the Hour-lines will be parallel one to another.

RULE III. If the *Fourth Tangent* prove to be greater then the *Old-Latitude*: Then, The *North Pole* is Elevated in *South Decliners*: But if the *Fourth Tangent* be lesser then the *Old-Latitude*, Then, the *South Pole* is Elevated in *North Decliners*.

II. In North Recliners.

RULE I. The *Fourth Tangent* found as before, is to be compared with the *Complement* of the *Old-Latitude*, and their *Difference* is the *New-Latitude*.

RULE II. If the *Fourth Tangent* prove to be equal to the *Complement* of the *Old-Latitude*: That *Declining Reclining Plane*, will be a *Polar Plane Declining*.

So, In the *Latitude* of 51 deg. 30 min. If a *Plane* should *Decline* from the *North* towards the *East* or *West* 60 deg. and also *Recline* from the *Zenith* 32 deg. 11 min. the *Fourth Tangent* will be found to be 38 deg. 30 min. Equal to the *Complement* of the *Old Latitude*: And will therefore, be a *Polar Declining Plane*.

II. To find the New Declination.

The Canon for Calculation.

As the Radius, Sine 90 deg	————	10.000000
To the Co-sine of the Reclina. 54 °	————	-9.769219
So is the Sine of the Old Decli. 24 ° 20'	————	9.614944
To the Sine of 14 deg. 1 min.	————	19.384163

Which 14 deg. 1 min. is the *New Declination*.

And

And now, if (according to the *Precepts* delivered in the 26th Chapter hereof) you do make an Upright South Dial Declining 14 deg. 1 min. in the Latitude of 72 deg. That Dial shall serve for a South Plane, in the Latitude of 51 d. 30 m. Declining 24 deg. 20 min. and Reclining 54 deg. And in such a Dial you will find the *Requisites* belonging thereunto, to be as the Table in the Margin. And thus much for making the Dial (according to its *New Latitude* and *New Declination*.)

But to apply this or the like Dial to the Reclining Plane in the Old Latitude, you are not to place the Hour-line of XII perpendicular to the Horizon, as in Upright Planes, but it must make an Angle with the Horizontal Line of the Reclining Plane: And therefore the quantity of that Angle must be first found. Therefore,

An Upright Dial Decl. 14				1
The Latitude of the Place 72				0
The Stiles height,				17 27
The Substiles dist. from Me. 4				30
The Difference of Merid. 14				41
From S to towards A.		From B to towards S.		
H. M.	Hours on the Plane	Hours on the Plane		
0 59	S 12	B	6	
1 59	S 1	B	7	
2 59	S 2	B	8	
3 59	S 3	B	9	
4 59	S 4	B	10	
5 59	S 5	B	11	

And

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III. To find the *Angle* made between the *Meridian* and the *Horizon*.

The Canon for Calculation.

Asthe Radius Sine 90	—————	10.000000
Is to the Sine of the Reclina. 54°	—————	9.907958
So is the Tang. of the Old De. 24° 20'	—————	9.655348
To the Tangent of 20° 6'	—————	<u>9.563296</u>

Whose *Complement* 69 deg. 54 min. is the *Angle* that the *Meridian* (or *Hour-line* of XII) must make with the *Horizontal Line* of the *Reclining Plane*. Thus for the *Quantity* of the *Angle*.

C H A P. XXX.

*How the Meridian-Line is to be placed in all those
Dials that are referred to a New Latitude.*

THE *Meridian Line* is not always to be taken for the Line of 12 at Mid-day (for it often represents the Mid-night) but for that part which helps to describe the *Dial*, and doth sometimes ascend above the *Horizontal Line*, and sometimes descend below it.

Now in all direct *Planes* that Re-or Incline, and in all upright Decliners the *Meridian* is the same with the Prime Vertical Lines, in all East or West Re-or Incliners it is the same with the *Horizontal Line*; in all the rest the *Meridian* doth ascend or descend from the *Horizontal Line*.

And for the better Understanding of its position, observe the Rules following.

In North Reclining Planes, if the *Declination* and *Reclination* be such as to make it become a
Polar

Polar Dial, then the *Meridian* doth descend below the *Horizontal Line* at that end which is contrary to the *Coast* of the *Declination*.

And if the *South Plane Inclines* and *Declines* so as it becomes a *Polar Dial*, the *Meridian* doth descend also from the contrary *Coast* of the *Declination*, and the fix of the *Clock Hour-line* is always the *Substile* in both.

If the *North Plane Reclines* and *Declines*, so that it becomes less than a *Polar Plane*, the *Meridian* ascends above the *Horizontal Line* the same way with the *Coast* of the *Declination*, and it doth represent 12 of the *Clock* at *Midnight*.

If the *Plane* be a *South Incliner*, and the *Inclination* and *Declination* be such, that it becomes less than a *Polar Plane*, the *Meridian* doth descend below the *Horizontal Line* the same way with the *Declination*.

If the *North Reclining Plane Reclines* and *Declines* so that it becomes more than a *Polar*, the *Meridian* doth descend below the *Horizontal Line*, and from that end which lies contrary to the *Coast* of the *Plane's Declination*.

If the *Plane* be a *South Incliner*, and *Inclines* and *Declines* so much that it becomes more than a *Polar Plane*, the *Meridian* doth ascend above the *Horizontal Line*, contrary to the *Coast* of the *Plane's Declination*, and is only serviceable to help to draw the *Dial*.

If a *North Plane Inclines* and *Declines* so much that it makes it less than an *Equinoctial Plane*, the *Meridian* will ascend above the *Horizontal-line* at that end which lies contrary to the *Coast* of the *Plane's Declination*.

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The *South Plane* that doth *Recline* and *Decline* so much that the *Plane* becomes less than an *Equinoctial Plane*, then the *Meridian* doth *Descend* below the *Horizontal Line* at that end which lies contrary to the *Coast of Declination*.

In all *North Inclining Planes*, that *Incline* and *Decline* so much that the *Plane* becomes more than an *Equinoctial Plane*, then the *Meridian* doth descend below the *Horizontal Line* at that end thereof that lies next to the *Coast of the Plane's Declination*.

And in all *South Recliners* and *Decliners*, if they *recline* and *decline* so much that it becomes more than a *Equinoctial Plane*, then the *Meridian* doth ascend above the *Horizontal Line* at that end which lies the same way of the *Plane's Declination*.

Now a *Plane* is said to be a *Polar Plane* when the *Reclination* and *Declination*, or the *Inclination* is such that it lies in the *Equinoctial Circle*; and it is said to be less than a *Polar Plane* when it falls between the *Zenith* and the *Equator*, and is more than a *Polar Plane*, when the *Plane* falls between the *Equator* and the *Horizon*: And these *Planes* are said to be *Equinoctial Planes* when the *Plane* shall so *Recline* and *Decline*, or *Incline* and *Decline* that the *Plane* falls into the *Pole*; that is, the *Plane* doth pass through both *Poles*; and by that reason the *Stile* doth make no *Angle* with the *Plane*, but it doth lie parallel to it, and those *Plains* are said to be less than *Equinoctial Planes*, that pass between the *Zenith* and the *Pole*, and those are said to be more than *Equinoctial Planes*, when the *Plane* falls between the *Pole* and the *Horizon*.

C H A P. XXXI.

How to place the Dial upon the Plane.

First draw a Line on the *Plane* parallel to the *Horizon*, which may be done by a Level or other convenient Instrument; then make choice of some convenient Place in that Line for the Center of your *Dial*; then with a Line of Chords or a Semicircle, draw the *Meridian* on the *Plane*, making it to ascend or descend according to the former Rules, so much as you find the distance of the *Meridian* and *Horizon* to be; then bring your *Paper-draught*, and placing the *Meridian* of the *Paper-draught* to lie on the *Meridian* of the *Plane*, you may Transfer the *Substile* and *Hour-lines* on the *Plane* having respect to the Coast of the *Meridian's Ascension* or *Descension* (if you have not erred in any working) then will the *Pattern* cut out for the *Stile* being set over the *Substile*, have respect to the elevated *Pole*.

C H A P. XXXII.

Of Declining and Inclining Planes and how Hour-lines may be described upon them.

HAVING in the former Chapters, given you several *Variety's* of Direct and Declining Reclining Dials; as first direct South and North Recliners: Secondly of direct East and West Recliners: Thirdly of Declining Recliners; it may now be expected that I should do the like for the Inclining Dials opposite to them, of which there are also as many *Varieties*, but seeing that these Inclining Dials are but the under faces of the Recliners, beholding

Q

the

the *Nadir*, at the same Angle that the *Recliners* behold the *Zenith*; the making of them differs nothing from the *Recliners* already mentioned; and all the *Requisites*, as *Meridian's Elevation*, *Substile's distance from 12*, and the *Stile's height*, and the *Hour Distances*, are the same both in the *Incliners*, as they were in the *Recliners*: Therefore having found the *Meridians Ascension* or *Descension* on your *Inclining Plane*, and draw a *Reclining Dial* on Paper for its upper face, place the *Meridian* of your *Paper-Dial* upon the *Meridian* of your *Inclining Plane*, so shall you find the *Stile* being set over the *Substile* to have respect to the *Elevated Pole*.

Note 1. if you are to seek what *Names* or *Numbers* to set to your *Hour-lines*, observe the *Note*, in the IX. Chapter, which Rule is General. And,

2. That no *South* erect or *Inclining Dial*, can have the *Sun* to shine on any *Hour-line* that falls above the *Horizontal-line*; and those *Hours* on the *North-Recliners* that falls below the *Horizontal-line*, belongs also to the *South Dials*.

Reflex Dialling.

C H A P. XXXIII

Reflection is best made by a piece of *Looking-Glass* which is so much the better, by how much it is *Thinner*; for the *Thickness* of it causeth a double ray of *Light* to be reflected, and requires a *Greater Elevation* of the *Sun's Beames* than a *Thin* one doth: It must be about *Seven times* the *Thickness* in breadth; and because *Glass* reflects from upper and neather *Superficies*, and so makes

two Spots, Colour the lower Superficies thereof with Oyl Colour, and it will make but one spot.

How to make a Dial upon a Cieling of a Room, that is parallel to a piece of Glas, placcd exactly Horizontal.

First, Determine the most convenient Point in the *Window* where to place the *Reflecting-Glass*, as near the *Cieling* as you can conveniently, provided it be not so near as that the *Cornish* of the *Window* will shadow the *Glass* when the *Sun* is high in *Summer*, suppose within 10 or a 11 Inches of the *Cieling*; then find a Point upon the *Cieling* directly over your *Glass*, thus: Hold a Line and Plummet to the *Cieling* just over it, and the place where the Plumline toucheth the *Cieling* is the Point; then through this Point draw a *Perpendicular* to your *Window*: Now if your *Window* be exactly *South*, this *perpendicular* upon the *Cieling* will be a *Meridian-line*; but if your *Window* declines the true *Meridian-line* will make an Angle with this *perpendicular*, equal to the Quantity of its *Declination*. Therefore having found the *Declination* of your *Window*, take 60 deg. of Chords, and setting one foot in the Point on the *Cieling*, with the other describe a *Circle*, and set thereon (from your *Perpendicular*) the *Declination* of your *Window*, toward your Right Hand if *West*, but, toward your Left Hand if *East*; then draw a Line from the point on which you describ'd your *Circle*, which Line shall be your *Meridian-line*.

2. Draw an *Horizontal-Dial* upon the back of some Table, or some Plaister-wall, or Floor.

3. Take the distance between the *Glass* and the *Cieling* with your *Compasses*; then come to your
Dial

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Dial on the *Wall*, and lay one side of your *Square* to the *Meridian-line*, and the other crossing the *Stile*; then move the *Square* upon the *Meridian-line*, till the extent of the *Compasses* does exactly touch both *Stile* and *Meridian-line*, and that point of the *Stile* which does touch the *Square*, may be called the *Glass-point*, from which erect a *perpendicular*, and where it cuts the *Meridian-line* make a point, which will be the *Equinoctial-point*, from which also erect a *perpendicular*, which will be a *Tangent*; then at some distance on which side of the *Equinoctial-point* you find most convenient, erect another *Tangent*; these two *Tangents* will cut the *Hour-lines* in the *Points*, which may be called the *Hour-points*.

4. Take the Distance between the *Glass-point* and *Equinoctial-point*, and extend it from the *Glass* to the *Meridian-line* on the *Cieling*, and where it toucheth, that is the *Equinoctial-point* upon the *Cieling*.

5. Set off correspondent *Tangent-lines* upon the *Cieling*, and making like *Hour-points*, through those *Points* draw the *Hour-lines*.

6. This *Dial* is nothing but an *Horizontal-Dial* inverted, the *Center* being in the *Air*, except you make a *North-Dial*, (which is seldom done) then it will be upon the *Cieling*, which you may find by its distance from the *Equinoctial-point*; then upon that *Center* describe a *Circle*, and likewise out of that *Center* erect a *Perpendicular* to the *Meridian-line*, for the *Hour-line* of 6; and you have no more to do but to set off from the *Hour-line* of 12, all the other *Hours* according to their spaces, in an *Horizontal-Dial*.

Lastly, Let your *Dial* on the *Wall*, Remain to take Distances for uses at any other time.

C Y L I N.

CYLINDRICAL DIALLING,

either

Concave or Conver.

C H A P. XXXIV.

Of those that fall in a Right Sphere, viz. such as lie Parallel to the Axis of the World, and their Bases Parallel to the Equinoctial.

HOur-lines may be drawn upon those *Cylinders*, with great ease and exactness, although in them there may be various Positions of the *Axis*.

SECT. I. If the *Axis* fall in the very *Center* of the *Base* of the *Cylinder*, then divide the *Circumference* of the *Base* of the *Cylinder*, in 24 equal parts, and draw lines from the *Center* to each of those Points, which will be the *Hour-lines* for the *Base* of the *Cylinder*: And where those *Lines* cut the *Circumference Lines*, drawn from them down the *Cylinder's Side*, they shall be the true *Hour-Lines*, which will be all Parallel each to one another.

SECT. II. If the *Point* of the *Axis*, fall not just in the *Center* of the *Base*, of the *Cylinder*, thro' that Point where the *Axis* falls, and the *Center* of the *Cylinder* draw a Line, and with a pair of *Compasses* take the nearest distance from the *Axis*.

Axis-point and describe a *Circle*, which divide into 24 equal parts. (beginning at the *Diameter* first drawn) Lines drawn from the *Axis Point*, through every one of them, and extend to the Side or *Circumference* of the *Base* of the *Cylinder*, shall be *Hour-lines*, and again Lines drawn from them down the *Side* of the *Cylinder* shall be *Hour-lines* also.

SECT. III. If the Point of the *Axis*, fall in any part of the *Periferie* of the *Cylinder's Base*. Then divide the *Circumference* of the *Cylinder's Base*, into 12 equal parts, beginning at the *Axis-Point*; Lines drawn from thence to the several Points, in the *Periferie* of the *Circle*, and also down the *Cylinder's Side*, they shall be the *Hour-Lines*.

SECT. IV. If the *Axis point* fall without the *Base*, of the *Cylinder*. Then the distance be-

your *Dial*, fasten a thin *Plane* of *Wood*, which will touch the *Pillar* in a *perpendicular-line*.

2. Take the *Declination* of this *Plane*, and draw a *Dial* upon it to that *Declination*; then prepare the *Stile* of this *Declining Plane*, long enough when produced through the *Plane*, to fix fast in the *Pillar*; but be sure that your *Stile* makes an *Angle* on the *Declining Plane*, equal to its true height; For *Example*, if your *Plane* decline 30° its height above the *Plane* is $32^{\circ} 37'$. Then by a *Candle* or your *Eye*, see where the *Stile* through every *Hour* directs upon the *Pillar*, on which places make marks; then cutting away your *Wooden Plane*, leaving your *Stile* fixt in the *Pillar*, draw your *Hour-lines* by the side of a *bending Ruler*, from the *Center* (which is where the *Stile* enters the *Pillar*) to the marks, and placing your *Hours*, your *Dial* is finished. By the like means you may

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Dial on the *Wall*, and lay one side of your *Square* to the *Meridian-line*, and the other crossing the *Stile*; then move the *Square* upon the *Meridian-line*, till the extent of the *Compasses* does exactly touch both *Stile* and *Meridian-line*, and that point of the *Stile* which does touch the *Square*, may be called the *Glass-point*, from which erect a *perpendicular*, and where it cuts the *Meridian-line* make a point, which will be the *Equinoctial-point*, from which also erect a *perpendicular*, which will be a *Tangent*; then at some distance on which side of the *Equinoctial-point* you find most convenient, erect another *Tangent*; these two *Tangents* will cut the *Hour-lines* in the *Points*, which may be called the *Hour-points*.

4. Take the Distance between the *Glass-point* and *Equinoctial-point*, and extend it from the *Glass* to the *Meridian-line* on the *Cieling*, and where it toucheth, that is the *Equinoctial-point* upon the *Cieling*.

5. Set off correspondent *Tangent-lines* upon the *Cieling*, and making like *Hour-points*, through those *Points* draw the *Hour-lines*.

6. This *Dial* is nothing but an *Horizontal-Dial* inverted, the *Center* being in the *Air*, except you make a *North-Dial*, (which is seldom done) then it will be upon the *Cieling*, which you may find by its distance from the *Equinoctial-point*; then upon that *Center* describe a *Circle*, and likewise out of that *Center* erect a *Perpendicular* to the *Meridian-line*, for the *Hour-line* of 6; and you have no more to do but to set off from the *Hour-line* of 12, all the other *Hours* according to their spaces, in an *Horizontal-Dial*.

Lastly, Let your *Dial* on the *Wall*, Remain to take Distances for uses at any other time.

C Y L I N.

CYLINDRICAL DIALLING,

either

Concave or Convex.

C H A P. XXXIV.

Of those that fall in a Right Sphere, viz. such as lie Parallel to the Axis of the World, and their Bases Parallel to the Equinoctial.

HOur-lines may be drawn upon those *Cylinders*, with great ease and exactness, although in them there may be various Positions of the *Axis*.

SECT. I. If the *Axis* fall in the very *Center* of the *Base* of the *Cylinder*, then divide the *Circumference* of the *Base* of the *Cylinder*, in 24 equal parts, and draw lines from the *Center* to each of those *Points*, which will be the *Hour-lines* for the *Base* of the *Cylinder*: And where those *Lines* cut the *Circumference Lines*, drawn from them down the *Cylinder's Side*, they shall be the true *Hour-Lines*, which will be all *Parallel* each to one another.

SECT. II. If the *Point* of the *Axis*, fall not just in the *Center* of the *Base*, of the *Cylinder*, thro' that *Point* where the *Axis* falls, and the *Center* of the *Cylinder* draw a *Line*, and with a pair of *Compasses* take the nearest distance from the *Axis*.

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Axis-point and describe a *Circle*, which divide into 24 equal parts. (beginning at the *Diameter* first drawn) Lines drawn from the *Axis Point*, through every one of them, and extend to the Side or *Circumference* of the *Base* of the *Cylinder*, shall be *Hour-lines*, and again Lines drawn from them down the Side of the *Cylinder* shall be *Hour-lines* also.

SECT. III. If the Point of the *Axis*, fall in any part of the *Periferie* of the *Cylinder's Base*. Then divide the *Circumference* of the *Cylinder's Base*, into 12 equal parts, beginning at the *Axis-Point*; Lines drawn from thence to the several Points, in the *Periferie* of the *Circle*, and also down the *Cylinder's Side*, they shall be the *Hour-Lines*.

SECT. IV. If the *Axis point* fall without the the *Base*, of the *Cylinder*. Then the distance between that Point, and the nearest part of the *Periferie*, of the *Cylinder's Base*, being made *Radi-us*, and a *Circle* be thereon described, and divided into 12 equal parts; then *Lines* drawn from the *Axis-Point*, through those Divisions shall each of them cut the *Periferie* of the *Cylinder's Base*, in two Points, from which Lines drawn from one to another (each to this correspondent) they shall be the *Hour-lines*, and from them *Point-lines* down the *Cylinder's Side*, must Parallel-Lines be drawn. Also,

CHAP. XXXV.

To make a Dial upon a Pillar of an House.

- I. **O**N that side of the *Pillar* (or on that place which is all one) where you would make your

your *Dial*, fasten a thin *Plane* of *Wood*, which will touch the *Pillar* in a *perpendicular-line*.

2. Take the *Declination* of this *Plane*, and draw a *Dial* upon it to that *Declination*; then prepare the *Stile* of this *Declining Plane*, long enough when produced through the *Plane*, to fix fast in the *Pillar*; but be sure that your *Stile* makes an *Angle* on the *Declining Plane*, equal to its true height; For *Example*, if your *Plane* decline 30° its height above the *Plane* is $32^{\circ} 37'$. Then by a *Candle* or your *Eye*, see where the *Stile* through every *Hour* directs upon the *Pillar*, on which places make marks; then cutting away your *Wooden Plane*, leaving your *Stile* fixt in the *Pillar*, draw your *Hour-lines* by the side of a *bending Ruler*, from the *Center* (which is where the *Stile* enters the *Pillar*) to the marks, and placing your *Hours*, your *Dial* is finished. By the like means you may project as many *Dials* as you please, upon a great *Globe*, or Two *Freestone Hemispheres*, or upon a *Cone*, or what you please.

OF THE FURNITURE

with which

Sun-Dials

may be Beautified ;

AND

*How to Describe such Furniture upon all Sorts of
Upright, Direct and Declining Dials, Geome-
trically.*

CHAP. XXXVI.

*Of such Circles of the Sphere, as are described
upon Sun Dials.*

MAny *Astronomical Conclusions*, may be per-
formed by describing of the *Circles* of the
Sphere upon *Sun-Dials*: Of which I have made
choice of these following.

1. The *Parallels* of the *Signs*, shewing in what
part

part of the *Zodiack* the *Sun* is, at all times of the Year.

2. The *Diurnal Arches*, shewing the length of the *Day* throughout the Year.

3. The *Hours* from the *Sun's Rising*, or *Setting*; or otherways called the *Babylonish* and *Italian Hours*.

4. The *Jewish Unequal*, or *Planitary Hours*.

5. The *Azimuths*, shewing in what quarter of the *World*, or upon what *Point* of the *Compass*, the *Sun's* on at all times of the *Day*.

C H A P. XXXVII

How to describe the Equinoctial, the two Tropicks, and other Parallels of Declination, upon any Sun-Dial.

THE two *Tropicks*, being the *Boundaries* of the *Sun's Course* (for he never exceeds those *Limits*,) therefore it is best, *first* to shew how they may be described; for between them all other *Circles* (either *Great* or *Small*) must be *Projected*, and the manner of describing them upon several *Planes* is *Various*.

SECT. I.

On the direct East or West, and Equinoctial Dials.

LET an *Example* be of direct *East-Dials* in the *Latitude* of 51 deg. 30 min.

How to describe the *Hour-lines* upon these
R Planes,

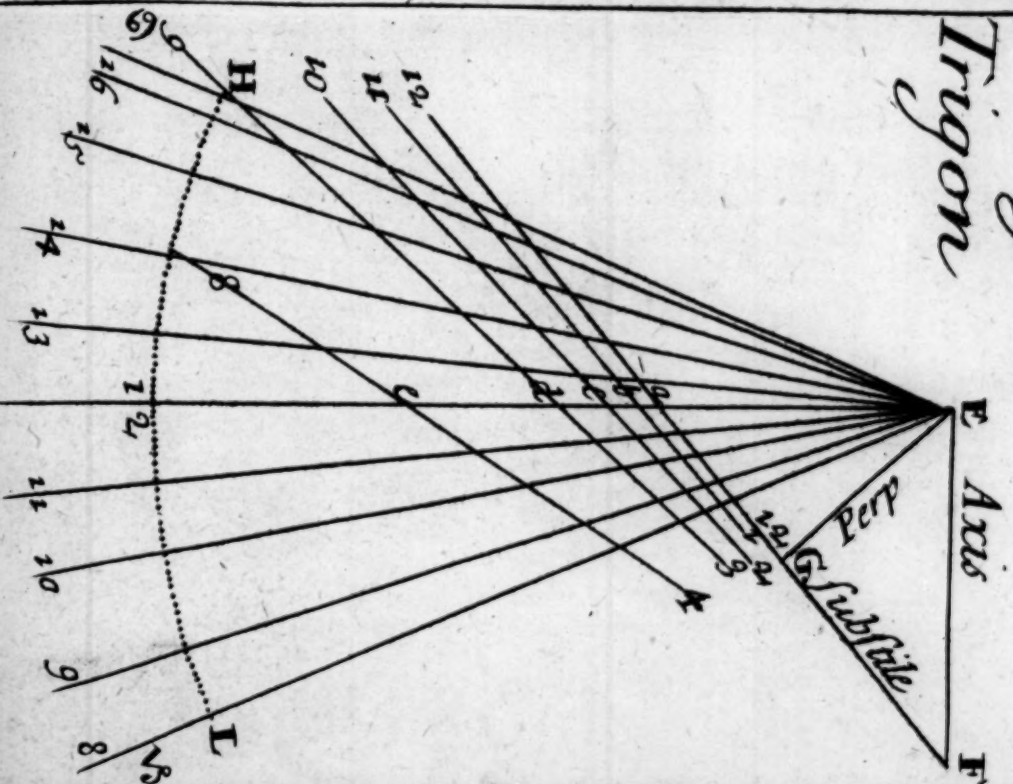
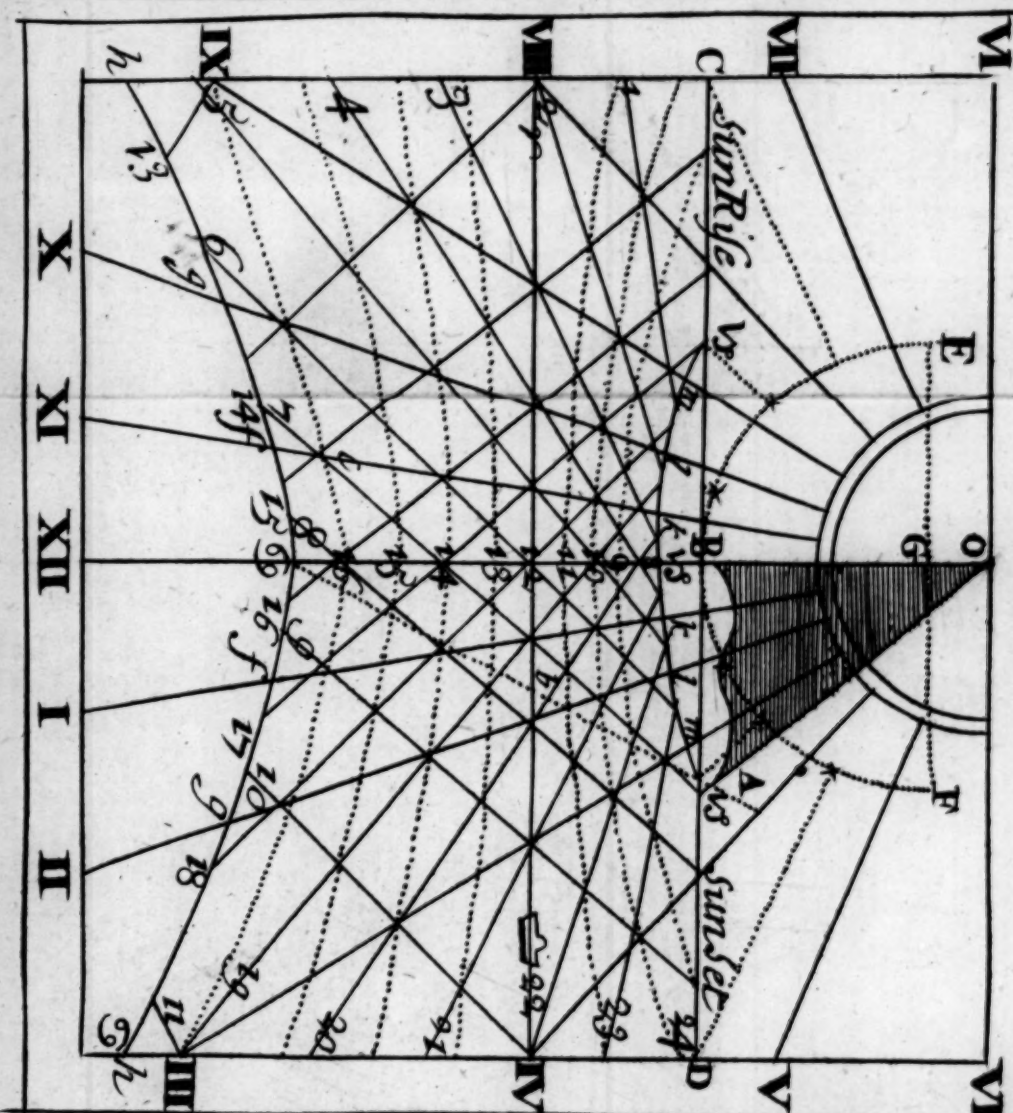
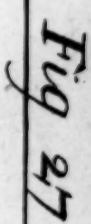
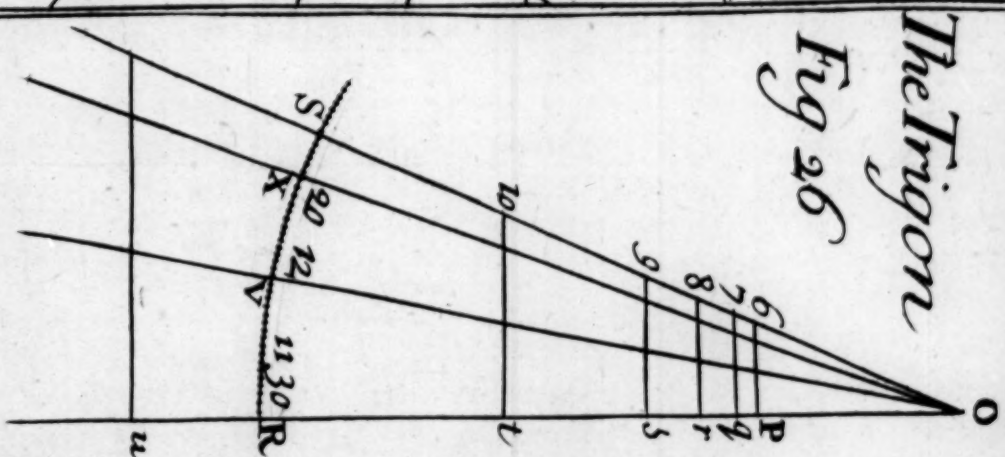
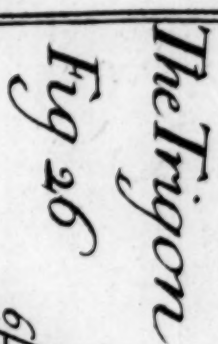
Planes, is shewed in the 4th and 22^d Chapters of this Book. Therefore such a *Dial* being drawn as in *Figure 25*, through the Foot of the *Perpendicular Stile*, as at *E*, draw a Line *M E N*, Parallel to the *Horizon*; for the *Horizontal-Line* in all *Planes*, must be drawn through the Foot of the *Perpendicular Stile*, and also through the Point wher the *Equinoctial Circle* crosseth the *Hour-Line* of *Six*. Your *Dial*, with the *Equinoctial-Line* hereof, *H E S*, being drawn, we come to describe the *Tropicks*.

1. Upon a piece of fine *Card-paste-board*, draw the Line *O R*, as in *Figure 26*, representing the *Equinoctial Line* in your *Dial*; and (because the *Tropicks* are 23 deg. 30 min. distant from the *Equinoctial*) with 60 deg. of your *Line of Chords*, upon the Point *O*, describe an *Arch* of a *Circle*, and set upon it 23 deg. 30 min. from *R* to *S*, and draw the Line *O S*, representing the two *Tropicks*; and the Angle *S O R*, you may call a *Trigon*.

2. Out of your *Dial*, take the length of the *Perpendicular Stile* *E G*, and set it upon your *Trigon* from *O* to *P*, and draw the Line *P 6* *Perpendicular* to *O R*. Also,

Take the distance from G, to the Intersection of the Hour line of	7	with the Equinoctial, and set it upon the Trigon from O, to	q	and draw the Lines	q	perpendicular to	7	OR.
	8		r		r		8	
	9		s		s		9	
	10		t		t		10	
	11		v		v		11	

Thus having prepared the *Trigon*, out of it take the distance *P 6*, and set it upon the 6 a *Clock Hour Line*, from *E* to *c*: Also take the distance *q 7*, and set it upon your *Dial* from *V*. to *b*, and from



from VII to *d*: Also take *r* 8, and set it upon your *Dial* from IV to *a*, and from VIII to *e*: Likewise take the distance *s* 9, and set it on your *Dial* from IX to *f*: Also, take *t* 10, and set it on your *Dial* from X to *g*; Lastly, take *v* 11, and set it on your *Dial* from XI to *h*.

These *Points a, b, c, d, e, f, g, h*, are the *Points* through which the *Tropick of Cancer* must be described; therefore if through them a Line be drawn with an even hand making no Angles, that shall be the *Tropick of Cancer*.

The *Tropick of Capricorn* may be described in the same manner, for if from your *Trigon* you take

The distance	{	<i>r</i> 8	} And set	{	VIII <i>k</i>	}
		<i>s</i> 9			IX <i>l</i>	
		<i>t</i> 10			X <i>m</i>	
		<i>v</i> 11			XI <i>n</i>	

Those shall be the *Points* through which the *Tropick of Capricorn* must be described; therefore if through *k l m n*, a Line be drawn with an even Hand, it shall be the *Tropick of Capricorn*: And,

When the Sun is in	{	Capricorn,	}	which	{	Decem. 11	}	the Shadow of the top of the <i>Stile</i> will pass along those respective Lines.
		Aries,				March, 10		
		Libra, or				Sept. 12		
		Cancer,				June, 11		

And according to this Method, may any other intermediate *Parallels of Declination* be inserted; as for *Example*: Suppose I would insert the *Parallels* of the *Sun's* entrance into the 12 *Signs*, *Aries* and *Libra* are inserted already, also *Cancer* and *Capricorn*; for the rest, as when the *Sun* enters into

Taurus,

Taurus	{	the Sun hath 11 deg. 30 min.	} of Declination.
Virgo			
Scorpio			
Pisces			
Gemini	{	the Sun hath 20 deg. 12 min.	
Leo			
Sagittarius			
Aquarius			

Therefore take 11 deg. 30 min. and 20 deg. 12 min. out of your Line of Chords, and set them upon the Arch R S of your *Trigon*, from R to V and X, and draw the two Lines O V and O X.

These *Parallels*, being thus put into your *Trigon*, they may be transferred into the *Dial*, in all respects as the *Tropicks* were; and as you see done in the *Figure XXVI*.

SECT. II.

In a Direct South or North Dial, Fig. 27.

HAVING drawn your *Dial* as is taught in Chapters 2, 3, or 17, 18, together with the *Stile*, your first work must be to proportion your *Stile* to your *Dial*; which to do, assume any convenient Point in the *Substile* (here the Line of XII) for the farthestmost *Tropick*, as here the Point ☿; then the *Stile's* height being 38 deg. 30 min. add 23 d. 30 min. thereto, the Sum is 62 deg. and that is the *Meridian Altitude* of the *Sun* when He enters *Cancer*, and the Complement thereof to 90 deg. is 28 deg. Therefore, upon the Point *Cancer*, make an Angle B ☿ A, to contain 28 deg. so shall the Line ☿ A cut the *Axis* of the *Stile* O A, in A; then from A let fall a Perpendicular to O ☿, as

(125)

as *AB* ; and so is your *Stile* proportioned to your *Dial* ; and the Line *CBD* (being drawn *Parallel* to the *Horizon*, through the Point *B*) shall be the *Horizontal-Line* of your *Dial*.

This done, prepare a *Trigon*, as *Figure 28*, in which make *EF* equal to *OA*, and *FG* equal to *OB*, and *EG*, to *AB*, the *Triangle EFG*, in the *Trigon*, equal to the *Triangle* of the *Stile* *OAB*, in the *Dial*.

From the Point *E*, draw a *Perpendicular* to *EF*, as *E 12*, for the *Equinoctial* ; and upon *E*, with 60 deg. of *Chords* describe the Arch *H 12 L*, and upon it set 23 deg 30 min. from *12* to *H* and *L*, and draw the Line *EH* for the *Tropick* of *Cancer*, and *EL* for the *Tropick* of *Capricorn* : Draw the *Substiler* Line *FG*, quite through the *Trigon*, crossing the *Equinoctial* in *a*, and both the *Tropicks*.

This done, out of your *Trigon* take the distance from *F* to *a*, and set it on your *Dial* from the *Center O* to *c*, through which Point draw the Line $\gamma c \simeq$ for the *Equinoctial* : Then from *O*, the *Center* of your *Dial*, take the distance to the Intersection of the *Hour-line* of 11, or 1 with the *Equinoctial*, and set it on the *Trigon*, from *F* to *b* : Also take the distance from *O*, to the Intersection of the *Hour-line* of 10 or 2, and set it from *F* to *c* : Likewise take the distance from *O*, to the Intersection of the *Hour-line* of 9 or 3, and set it from *F* to *d* : Lastly, the distance from *O*, to the Intersection of 8 or 4, with the *Equinoctial*, set from *F* to *e* ; and draw the Lines *F a*, *F b*, *F c*, *F d*, *F e*, through the *Trigon*, making them 12, 11, 10, 9, 8, and 1, 2, 3, 4, &c. Now to find the Points upon the *Dial*, through which the *Tropicks* must pass ;
The

The Dist-
ance from
F to

{ 12 }
{ 11 }
{ 10 }
{ 9 }
{ 8 }

will reach
from O,
the Center
of the Dial
to

{ 5 }
{ f }
{ g }
{ b }

on the
Hour-
Lines
of

{ 12 }
{ 11 }
{ 10 }
{ 9 }

{ 1 }
{ 2 }
{ 3 }

Through which Points the *Tropick* of *Cancer* must be drawn with an even Hand: And,

The Dist-
ance from
F to

{ 12 }
{ 1 }
{ 2 }
{ 3 }
{ 4 }

will reach
from O,
the Center
of the Dial
to

{ vs }
{ k }
{ l }
{ m }
{ vs }

upon
the
Hour-
Lines
of

{ 12 }
{ 11 }
{ 10 }
{ 9 }
{ 8 }

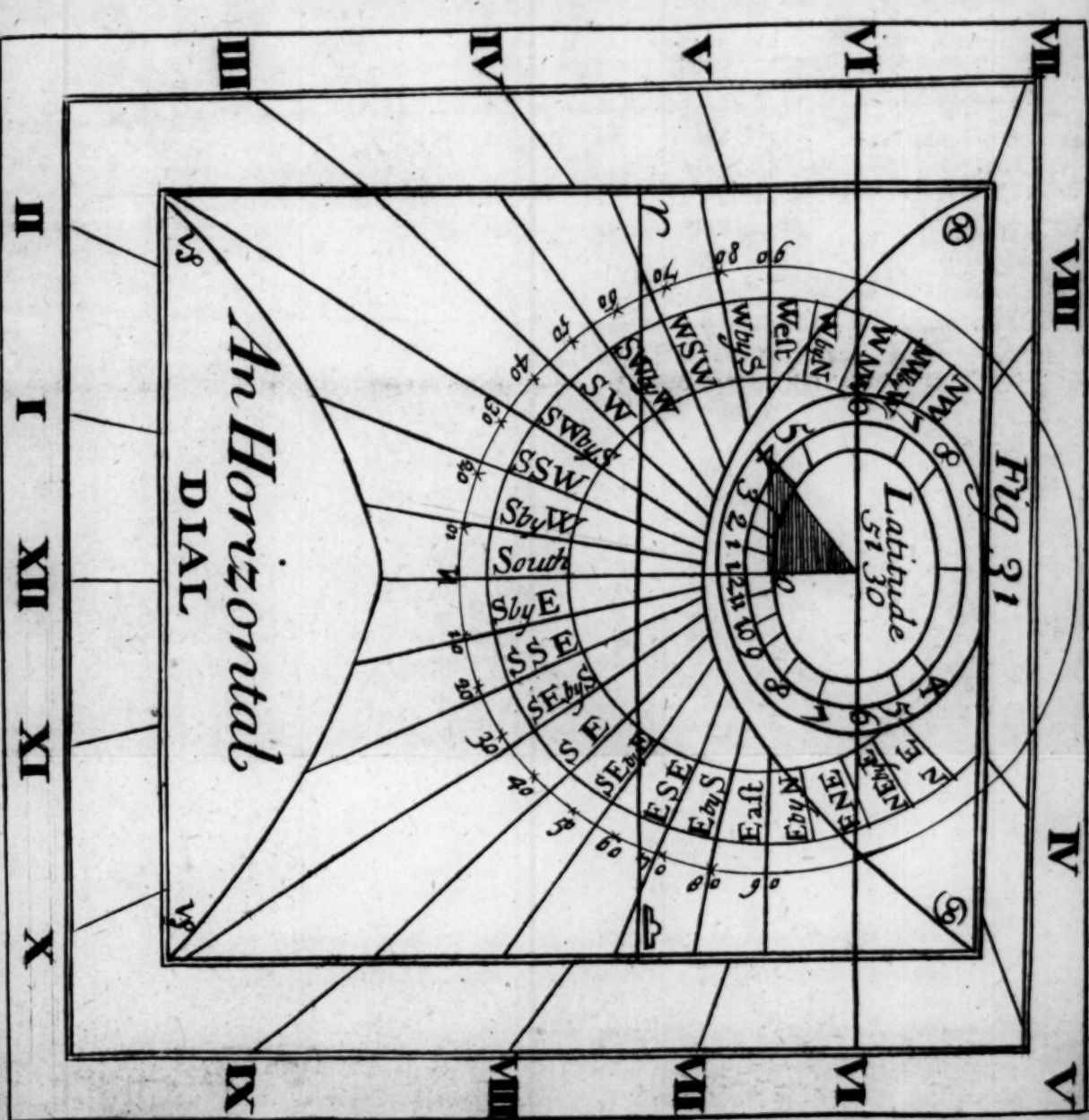
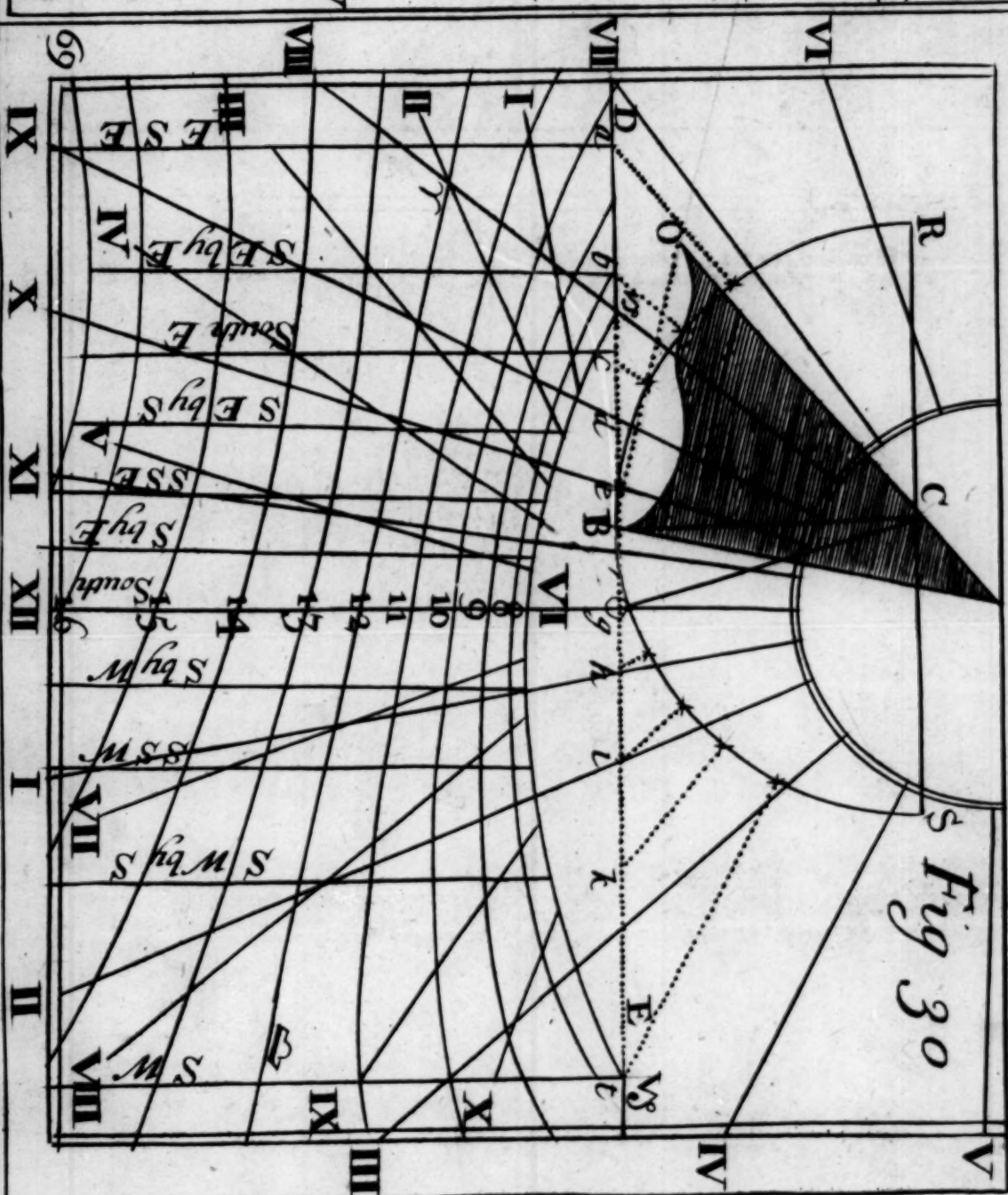
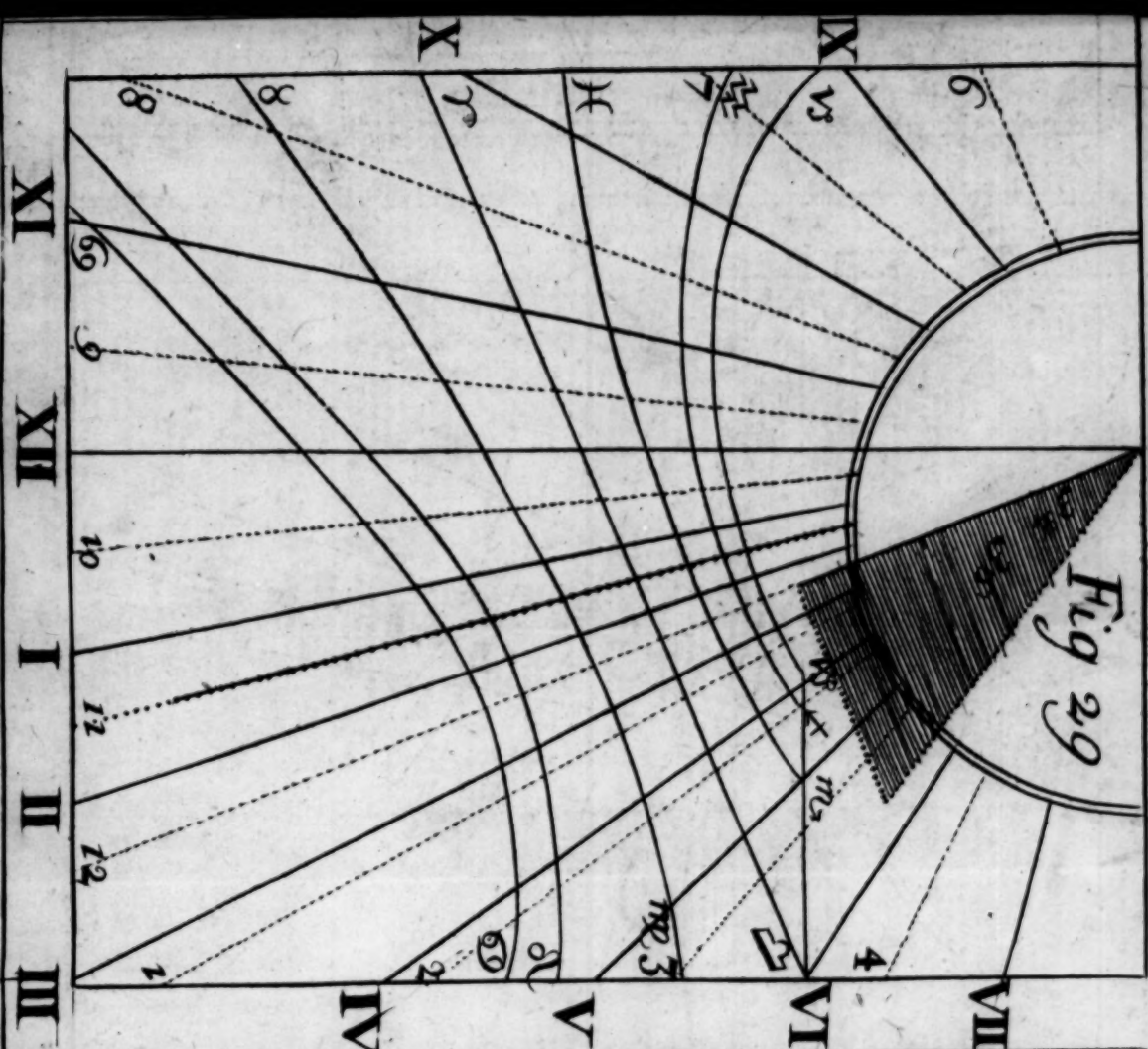
{ 12 }
{ 1 }
{ 2 }
{ 3 }
{ 4 }

Through which Points the *Tropick* of *Capricorn* must be drawn. And thus you have the *Equinoctial*, and the two *Tropicks*, described upon a *Direct South Dial*.

S E C T III.

How to describe the Equinoctial, and the two Tropicks on any Upright Dial Declining; or in such as both Recline and Decline.

AN Example of an Upright Dial Declining from the South Westward 30 deg. The making of these *Dials* is Taught in the 5th and 8th or 26th, and 27th Chapters of this Book: Therefore having drawn such a *Dial*, with the *Stile* and *Substile* in a Due Position, you will find the height of the *Stile* to be 32 deg. 37 min. First, make an *Horizontal Dial* for the Latitude of 32deg, 37 min.



37 min. as in the Declining Dial, *Figure 29* where the *Substiler Line* is taken for the *Hour-line* of 12, as it is there marked, and the other Pricked-lines, are the *Hour-lines* of an *Horizontal Dial* for the *Latitude* of 32 deg. 37 min. Now, if according to the directions of the foregoing *Sections* you make *Trigon*, and insert the *Equinoctial*, and *Tropicks*; and afterwards expunge the obscure Lines of the *Horizontal Dial*, the *Equinoctial Tropicks*, and *Horizontal Line* will be the same, as if they had been inserted from the true *Hour-Lines* belonging to the *Dial Plane*.

And as the *Tropicks* were described, so likewise may the *Parallel*, of the *Sun's* Enterance into the other Signs, be inserted if into your *Trigon*, you put there *Arches* of *Declinations* from the *Equinoctial*, Namely 11 deg. 30 min. and 20 deg. 12 min. And so are the *Parallels* of the Signs put into the *Dial*, *Figure 29*.

And in any *Dial*, also may the *Diurnal Arches* be described, if you put into the *Trigon* such *Declinations*, as the *Sun* hath from the *Equinoctial*, when the Days is either,

		Hours long, as	[deg. min.]			
{ vs 8 9 10 11 12 }	{ or 16 15 14 13 12 }		}			
					[deg. min.]	
					{ 23 30 }	
					{ 21 40 }	
					{ 16 55 }	
					{ 11 37 }	
					{ 5 55 }	
					{ 0 0 }	

So are the
Durnal Ar-
ches put in-
to the *South-*
Dial repre-
sented by the
Prickedlines
there, in *Fig.*
27 and the

Trigon thereunto belonging is *Fig. 28*.

C H A P. XXXVIII

How the Hours from the Sun's Rising and Setting, are to be described into all sorts of Sun-Dials.

THE *Hours* from *Sun-Rising*, are called the *Babylonish Hours*, for they begin their Day at the *Sun's Rising*; and the *Hours* from *Sun-Setting*, are called the *Italian Hours*, for in *Italy* they account their Time from the *Setting* of the *Sun* the Day preceding.

The manner how to describe the *Hours* (is the same in all *Planes*, and) is easily performed: And because that upon a full *South*, or *Horizontal Dial*, they will apper most Uniform; I have therefore made choice of a *Direct South Dial*, as in *Figure 27.* to describe them: Your *Dial* being drawn, and the *Equinoctial* $\text{V} \approx$, the two *Tropicks* $\text{S} \approx$, and vsvs , and the *Horizontal-line*, *Sun-Rise* — *Sun-Set*; you must (by the last Chap.) describe two obscure *Parallels* of Declination, one when the Day is 8 Hours long, as $\odot 8 \odot$, and the other when the Day is 16 Hours long, as $\ast 16 \ast$, the *Equinoctial* being the Parallel when the Day is 12 Hours long.

Being thus far prepared, the inscription of these *Hours* will be very easie; for it is plain, that when the Day is but 8 Hours long, that the *Sun* *Rises* at 8 in the Morning; and the first Line after the *Sun's Rising* is 9 in the Morning; also when the Day is 12 Hours long, the *Sun* *Rises* at 6 in the Morning, and the first Hour after, is 7

in the Morning; Lastly, when the Day is 16 Hours long, the *Sun Rises* at 4 in the Morning, and the next Hour after is 5 in the Morning: And all the rest as in this Table. Therefore, a straight Line drawn through the intersection of these Hours Lines, with the *Parallels* of 8, 12 and 16 Hours, shall be the first Hour after the *Sun Rising* all the Year long.

Length of Days

	viii	xi	xv
i	9	7	5
ii	10	8	6
iii	11	9	7
iv	12	10	8
v	1	11	9
vi	2	12	10
vii	3	1	11
viii	4	2	12
ix	5	3	1
x	6	4	2
xi	7	5	3

In the like manner, if you would insert the seventh after the *Sun's Rising*: By the Table you see, that the *Parallel* of *viii Hours*, for the length of the Day, the seventh Hour from *Sun Rising* is 3 in the afternoon; therefore observe where the *Hour-line* of 3 crosseth the *Parallel* of *viii Hours*, which is at *a*. Also by the Table you see that in the *Parallel* of *xii Hours*, for the length of the Day, the seventh Hour from *Sun-Rising*, is 1 in the Afternoon; therefore observe where the *Hour-line*

of 1 crosseth the *Equinoctial*, which is at *b*. Thirdly, by the Table you see, that in the *Parallel* of *xvi Hours*, for the length of the Day, the seventh Hour from the *Sun's Rising* is 11 in the Forenoon; and therefore observe where the *Hour-line* of 11 crosseth the *Parallel* of *xvi Hours*, for the length of the Day, which at *c*; so shall a right-line drawn through these *Points*, *a b c*, be the seventh Hour after the *Sun's Rising* throughout the Year:

And thus by the help of this Table, you may draw all the *Hour-lines* from the *Sun's Rising*, as you see them drawn, and numbred as in *Figure 27*.

In the same manner, as the *Hours* from the *Sun's Rising* (which are the *Babylonish Hours*) were drawn, may the *Hours* from the *Sun's Setting* (which are the *Italian Hours*) be drawn: The difference being only in the numbring of them; the *Hours* from *Sun Rising*, being numbred from the *West* end of the *Horizontal-line*, by 1, 2, 3, 4, 5, 6, 7, 8, 9, 10: And the *Hours* from *Sun-Setting*, from the *East* end of the *Horizontal-line* backwards, by 23, 22, 21, 20, 19, 18, 17, 16, 15; as appears in *Figure 27*.

A Corollary arising from the Work of this Chapter.

The *Hour-lines* from *Sun-Rising* and *Setting*, being described upon any *Dial*, as is before taught, there will by their correspondent intersections one with another, be Points produced through which if *Lines* be drawn, with an even hand, the same shall be the *Parallels*, of the length of the *Day*, and such are *Pricked Lines* in *Figures 27*, numbred upon the *Meridian-Line* of the *Dial*, by 8, 9, 10, 11, 12, 13, 14, 15, 16.

C H A P. XXXIX.

Of the Jewish, or Old Unequal, or Plantetyp-hours, and how they may be described upon any Sun-Dial.

THE Ancients, account their *Day*, was from the *Sun's Rising* in the *Morning*, till it's *Setting* in the *Evening*, which space of time they did divide into *Twelve equal Parts*, were it long

or short; so that in the *Summer*, all the Time that the *Sun* hath *North-Declination*, the *Hours* of their *Day*, was longer than a *Common equal Hour*; and in the *Winter* when the *Sun* hath *South-Declination* the *Hours* of their *Day* were shorter than a common equal *Hour*; but when the *Sun* is in the *Equinoctial*, their *Hours* are equal to our common *Hours*.

The *Inscription* of these *Hour-lines*, into all sorts of *Sun-Dials* is very easie, being much like the *Inscription* of the *Italian*, and *Babylonish Hours*, Taught in the last Chapter.

Having drawn your *Dial*, with *Hours*, halves, and quarters; and also the *Equinoctial*, the two *Tropicks*, and *Horizontal-line*; and also the Pa-

The Few ish.	The Pa ralls of 15 H.		Equi- nocti- al.	The Pa- rall of 9 H.	
Hours.	H.	M.		H.	M.
i	5	45	7	8	15
ii	7	00	8	9	00
iii	8	15	9	9	45
iv	9	30	10	10	30
v	10	45	11	11	15
vi	12	00	12	12	00
vii	1	15	1	0	45
viii	2	30	2	1	30
ix	3	45	3	2	15
x	5	00	4	3	00
xi	6	15	5	3	45
xii	7	30	6	1	30

ralls of the length of the *Day*, as is done in *Figure 28*, which a *South-Dial Declining Eastward* 15 deg. you must make choice of two *Parallels* of the length of the *Day*, which must be both of them be equi-distant from the *Equinoctial*, which let be the *Parallels* of 9 *Hours*, and 15 *Hours*, for those two *Parallels* are most convenient for this purpose

purpose; because the *Jewish Hours*, in those *Parallels* will justly fall upon the even *Hours*, halves, or quarter: Now the *Points* through which the *Jewish* hours are to be drawn, as the Table before will direct; wherein you see, that the first *Jewish* hour is to be drawn through 5 hours, 45 min. in the *Parallel* of 15 hours, through 7 in the *Equinoctial*, and through 8 hours and 15 min. in the *Parallel* of 9 hours: In like manner the second *Jewish* hour must be drawn through the intersection of 7 hours, in the *Parallel* of 15 hours, through 8 in the *Equinoctial*; and through 9 in the *Parallel* of 9 hours: And so must all the rest of them be described as the Table does direct, and as you see done in *Figure 30*. And in this manner, by the help of this Table, may they be described in all sorts of *Planes*, whither *Direct*, *Reclining*, or *Declining*.

CHAP. XL:

How the Azimuth must be described, upon any Sun-Dial.

THE *Azimuths* are great Circles, and being projected upon all *Dials*, become straight Lines; and they are variously described, according as the *Dial-Plane* is Scituated, particulars of which follow.

S E C T.

S E C T. I.

On an Horizontal Dial.

IN these *Dials* the *Azimuths* are most easily described: For, your *Dial* being drawn, with the *Tropicks* thereon, you have no more to do, then upon the foot of the *perpendicular Stile* as at O (in *Figure 31.*) as a *Center*, to describe a *Circle*, as $\odot$, N $\odot$, which you may divide into 32 equal points (beginning at N) answering to the 32 points of the *Mariner's Compass*, or else you may divide it into 90 equal parts or degrees, noted with $***$, &c. and through those points draw streight Lines from O, the foot of the *perpendicular Stile*, and they shall be the true *Azimuth* upon an *Horizontal Dial*, which you may denominate by South, S. by E. S.S.E. S.E. by S. &c. as you see done in *Figure 31.*

S E C T. II.

Upon a Direct East, or West Dial, Fig. 25.

HAVING made an *East Dial* and therein inserted the *Equinoctial*, and the two *Tropicks*, and the *Horizontal Line*, you may proceed to describe the *Azimuths* in this manner;

Upon the point E, of the *Horizontal Line* of your *Dial*, MEN, erect the *Perpendicular* EQ,
equal

equal to EG (the height of your *Stile* of your *Dial*) and upon Q, as a Center, describe the ~~Quadrant~~ QEE, and divide it into eight equal parts, representing one quarter of the *Mariner's Compass*, and from Q through those Points, draw Lines to the *Horizontal Line* MEN, as ○○○○○○; from which Points let fall Perpendiculars from the *Horizontal Line*, and they shall be the *Azimuths* between the *South* and the *East*; and for those Points which fall between the *East* and the *North*, as E. by N. — E.N.E. — N.E. by N. — are the same Distances set upon the *Horizontal Line* from E, towards the Left hand, as the first three *Azimuths* towards your Right hand, is as ○○○○; through which Points, if lines be drawn perpendicular to to the *Horizontal Line*, they shall be the *Azimuths*, or Points of the *Compass*, between the *East* and the *North*: As in Fig. 25. And as the *East Dial* contains the *Azimuths* between the *South* and the *East*: The *West Dial* must contain those between the *South* and the *West*.

SECT. III.

Upon the Direct South upright Dial.

Fig. 27.

THE Dial with the *Equinoctial*, and the two *Tropicks* and the *Horizontal Line* described thereon, the *Azimuths* may be inserted thereon as followeth:

First,

First, take the length of the *perpendicular Stile* of your *Dial* AB, and set it upon the *Meridian* of your *Dial* from B to G.

Secondly, With the distance GB, upon G, describe the Circle EBF, which divide into 16 equal parts (if you will) but I have here divided it but into 8, to shew the manner of the Work, in the Points ****, &c. Through which Points from G, draw obscure lines extending them till they touch the *Horizontal Line* of your *Dial* CBD, now if from these Points of touching you draw lines perpendicular to the *Horizontal Line* between the *Tropicks*, (or Parallels to the line of 12,) they shall be the *Azimuth* required.

Note, I have not drawn the lines themselves in this Fig. 27. because the *Dial* is full enough of *Lines* already.

SECT. IV.

Upon the South Declining Dial. Fig. 30.

AN Example shall be of a *South Dial*, Declining Eastwards 15 deg.

Such a *Dial* being drawn, and the *Equinoctial*, *Tropicks*, and the *Horizontal Line* inserted thereon: Upon the Point B of the *Horizontal Line* erect the *Perpendicular* BC, equal to BO, the *Perpendicular Stile* of your *Dial*; upon which Point C, describe the Semicircle RBS, which done, lay a *Ruler* to C, and the Point O, where the *Hour-line* of 12 crosseth the *Horizontal Line*, and where the *Ruler* cuts the Semicircle RBS, at that Point begin to divide it into 16 equal parts,

at

at the Points ***, &c. And from the Center *C*, draw lines obscurely through those Points, extending them till they touch the *Horizontal Line DE*, in the Points *a b c d e f g h i k* and *l*, through these Points Right lines being drawn, Parallel to the *Meridian*, shall be the *Azimuth* desired; which you must number according to the *Scituation* of the *Plane*: Namely the *Western Azimuths* on the *East* side of the *Meridian*, and the *East Azimuths* on the *West* side of the *Meridian*, as you may see in *Figure 30*.

C H A P. XLI

How to make a Sun Dial by which a Blind Man may know the Hour of the Day.

LET a glass *Globe*, whose Diameter is 2 or 3 Inches fil'd with clear water, be placed in the Middle of a *Semi-Armilar Sphere*, consisting of some *Iron Circles*, which represent *Hour-Circles*: If when the Sun shines, you apply your *Hand* or *Fingers* to these *Iron Circles*, that in which you feel the Hand to be Burned by the Solar Rays, is the *Horary Circle* in which the Sun Exists.

For the glass *Globe* full with water, so unites the Solar Rays, that they Burn at some distance: If the *Circles* of the *Armillar Sphere*, be precisely in the distance of the *Focus*, the *Focus* will come into that which is Diametrically opposite to the Sun, and there the *Hour* of the day may be felt.

Soli Deo Gloria.

